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ENGINEERING EDUCATION

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THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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Ames, Iowa June 25–29, 1956

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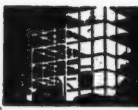

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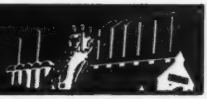

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► . . . . That if you haven't "Aimed for Ames in '56" by now you had better change your sights immediately? You have all received the Preliminary Program and know the papers and talks will be good. It will be another three-ring circus, it is true, but there will still be time to visit with old friends and make new ones. Dean Downie Smith hasn't taken over full responsibility for the weather with the same conviction that Dean Eric Walker did last year, but I know both he and the local committee are putting all the pressure they can on the "weather department."

► . . . . That the way to get to Ames is repeated for your convenience?

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► . . . . That 5500 copies of the brochure advertising the three summer schools—Construction Education, Engineering Drawing, and Humanistic-Social—have been mailed to prospective attendees? The Secretary's office sent out about 800 for whom there are addressograph plates (deans, officers, committees, etc.) and the respective Divisions sent out the others. Don't forget these summer schools in "Aiming for Ames." The dates and the Iowa State College representatives from whom information can be obtained are:

Construction Education: June 29–July 1
W. T. Hosmer, Professor of Civil Engineering
Engineering Drawing: June 20–24
J. S. Rising, Head, Department of Engineering Drawing
Humanistic-Social: June 28–30
J. E. Humphrey, Associate Professor of English and Speech

► . . . . That there were 168 applications for the 60 places in the Summer Institute for Nuclear Engineering to be held at Argonne National Laboratory from June 25 to August 17, 1956, with joint sponsorship by ASEE, NSF, AEC, and Northwestern University? About 80 engineering schools nominated men from their faculties, indicating a growing interest on the part of colleges and universities in developing staffs competent to give adequate instruction in this rapidly expanding field of engineering.

According to the *Nuclear Energy Education Newsletter* prepared by our Atomic Energy Education Committee (if you want to receive it write to the Secretary's office) the purpose of the Institute is threefold: (1) to give all its members a survey of the available sources of unclassified information in the atomic energy field, and of laboratory teaching methods particularly relevant to the field of nuclear power; (2) to give all its members in the brief time available some feeling of the interrelation of the many scientific and engineering disciplines involved in the successful design of a nuclear power enterprise; (3) to give each member a somewhat more detailed knowledge of some one part of the whole field, usually that part most closely related to his previous interest and experience.

For the first six weeks of the Institute, members will attend approximately five lectures a day three days a week. They will spend the other two days of these weeks in the laboratory, sometimes performing experiments and at other times witnessing laboratory demonstrations. For the final two weeks, each member will devote his principal effort to advanced lectures and laboratory work in the specialty of his choice.

Because of the large number of applications, plans were immediately developed to extend the program by having a similar Institute for 30 men at Brookhaven National Laboratory. The NSF has approved the program extension, but funds must come from the next fiscal year, and Congress hasn't appropriated the money as yet.

► . . . . That the minutes of the meeting of the Executive Board at Denver, Colorado, April 27 and 28, are on page 807 of this issue? Some of the highlights follow, but you will want to read the minutes to comprehend more thoroughly the many activities of the Society.

1. The "Survey of the Teaching of English In Engineering Schools" was recommended to the General Council for approval at the recent meeting of the Executive Board. Neither the Evaluation Report nor the Humanistic-Social Report now includes English, whether oral or written. Thus the study is necessary if the Society is to include all aspects of engineering education in its present "look ahead" surveys. The proposed financing was presented, and if the General Council approves the policy at its June meeting, the English Division is ready to proceed.

2. The Executive Board voted to recommend to the Constitution and

By Laws Committee and the Society Functions Committee a provision that *all* officers of the Society be members of the General Council for three years beyond the stated terms of office. At present only the President continues. The basis for the action is to make greater use of the experience and knowledge acquired by officers during their active terms.

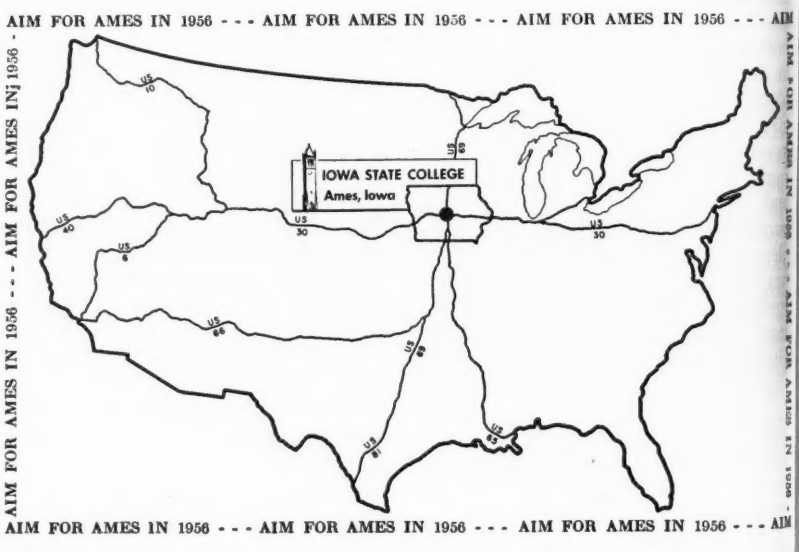
3. "Vincent Bendix Award" is the name of the gold medal to be given annually for outstanding research in colleges of engineering? The General Council authorized the Executive Board to approve a name, and ECRC recommended that of Vincent Bendix. The Bendix Aviation Corporation is assuming sponsorship of the medal.

4. At the June meeting of the General Council "dropping from membership" action will be taken on all who are still two years delinquent in dues payments as of the coming July 1. The Executive Board authorized the Secretary to follow such a policy. About 400 names are included. And there are about 300 who won't get the JOURNAL next year until they pay this year's dues. That may be unfortunate for the delinquents; we are being told kind things about the changes already made; still others are being planned.

5. Ways of increasing Society income for travel expenses were discussed. All lamented the inability to pay expenses for members of the General Council, for representatives of the Society on committees of other societies, etc., in attending meetings. To get something started, it was voted to recommend to the General Council that dues of Associate Institutional Members be increased from $50 to $150 per year, and that an *ad hoc* committee of the General Council be appointed to draft an appropriate letter which would notify the Associate Institutional Members of the change.

► . . . . That I hope to see you at Ames?

W. LEIGHTON COLLINS,
Secretary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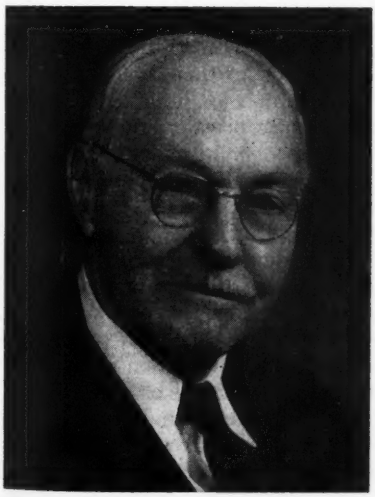
ENGINEERING RESEARCH AT IOWA STATE COLLEGE

I. The Engineering Experiment Station

Iowa State College was one of the first educational institutions in the country to provide for organized research activity through the establishment of an engineering experiment station. In response to the proddings of Iowa State's vigorous dean of engineering, Anson Marston (a past president of ASEE), the Iowa General Assembly in 1904 voted a sum of money for this purpose.

Before that time, the departments of the College had carried on their work independently. Through his action, however, Iowa State was able to share with the University of Illinois the distinction of being one of the first two institutions to set up engineering experiment stations. Investigations were at once started of value to the industrial, municipal, and agricultural interests of the state.



Anson Marston, first Dean of Engineering, Iowa State College, and first Director of the Engineering Experiment Station, 1904–1932; Dean Emeritus, 1932–1949. He was President of ASEE 1914–1915.

Since then, the purposes of the Station have always been to foster and develop the industries of Iowa through engineering research and the publication of bulletins. Aid has been given constantly to develop raw materials and natural resources in the state, to increase the effective utilization of agricultural by-products, and to assist in the solution of engineering problems which face the various branches of government.

Early Progress

The General Assembly of 1904 lost no time in availing itself of the engineering research talent available on the Iowa State campus. That same year, the College was designated as the State Highway Commission, with the deans of engineering and agriculture entrusted jointly with responsibility for the commission's activities.

The first and second bulletins of the Engineering Experiment Station were issued before the end of September, 1904. Both of these bulletins showed the organization of the Station and listed a staff of five engineers. Dean Marston had proceeded with his usual dispatch in beginning the active work of the Station as soon as the legislative appropriations were available on July 1, 1904. One of the

early bulletins dealt with "The Good Roads Problem of Iowa." Though in 1913 the Highway Commission became a separate branch of the State Government's activities, the Station still does considerable work for the Commission under grants-in-aid from highway funds.

The early work of the Station included three principal types of activity: (1) engineering and scientific investigations, (2) dissemination of educational information on technical subjects, and (3) tests and analyses of engineering materials. All three types of work were pursued actively in the field of civil engineering, particularly with water supply and sewage disposal systems, drainage, and highway materials and construction. Other work dealt with problems of mining and ceramic industries of the state and with rural electrification.

In 1913, the Engineering Extension Service was established by the legislature as an independent agency to carry on informational activities in the technical field. This work was then removed from the authority of the Engineering Experiment Station. As commercial testing laboratories were established in the state, the work on tests and analysis of materials was gradually turned over to them in so far as possible.

Broad Program

Today, active work is under way on over 30 major research projects as well as on other minor investigations. These projects include activities in all of the major engineering fields. Some of the more extensive investigations are concerned with the utilization of agricultural by-products, the manufacture of fertilizers, the treatment of garbage, extraction of vegetable oils, the development of highway materials and construction methods, soil mechanics, analysis of problems in electrical transmission and distribution, and creativeness in the field of machine design.

Distribution of research results has always been an important activity of the Station. A total of 177 major Engineering Experiment Station bulletins have been issued, and numerous papers have been presented before the major engineering societies reporting the results of Station research.

The activities of the Iowa Engineering Experiment Station are supported partly by legislative appropriations and partly by contracts with sponsoring organizations. The governmental sponsors include both military and non-military groups. The budget for the current fiscal year is $414,000, of which 40 per cent comes from state appropriations. The remaining 60 per cent is obtained through research contracts with the Iowa State Highway Commission, the Federal Government, or private industry.

It is a definite policy of the Engineering Experiment Station that its research work be closely coordinated with the teaching activities of the College. Practically all of the 79 staff members have part-time teaching responsibilities, and in this way the results of current research are brought directly to the attention of Engineering students. Some of the staff members are graduate students on a part-time basis, who are thus able to obtain practical research experience while they study for advanced degrees. In addition, a number of qualified undergraduate students are employed part-time in a mutually profitable relationship.

By historical tradition, the Dean of Engineering at Iowa State College also serves as Director of the Engineering Experiment Station. Since its establishment 52 years ago, the Station has had three such directors: Anson Marston, Thomas R. Agg, and the present Dean, J. F. Downie Smith. The Associate Director is George R. Town.

Many of those visiting Iowa State College to attend the ASEE meeting in June, 1956, will undoubtedly be interested in talking to the staff members who are conducting the various research projects and obtaining first-hand information about methods and equipment. The Iowa Engineering Experiment Station issues a warm invitation for all ASEE members to visit the Station, and promises that every possible courtesy will be extended to make their visits interesting and profitable.

II. The Institute for Atomic Research

During World War II, Iowa State College played a leading part in the basic research which resulted in large-scale release of atomic energy. The Iowa State Board of Education felt that the College should maintain this leadership after the war. Therefore, on November 1, 1945, President Charles E. Friley was authorized to establish the Iowa State College Institute for Atomic Research. The Institute was set up as a separate budgetary division of the College and operates in a manner similar to that of the graduate college and experiment stations. It is thus able to conduct joint research programs on the basis of voluntary cooperation and agreement with the various deans and department heads.

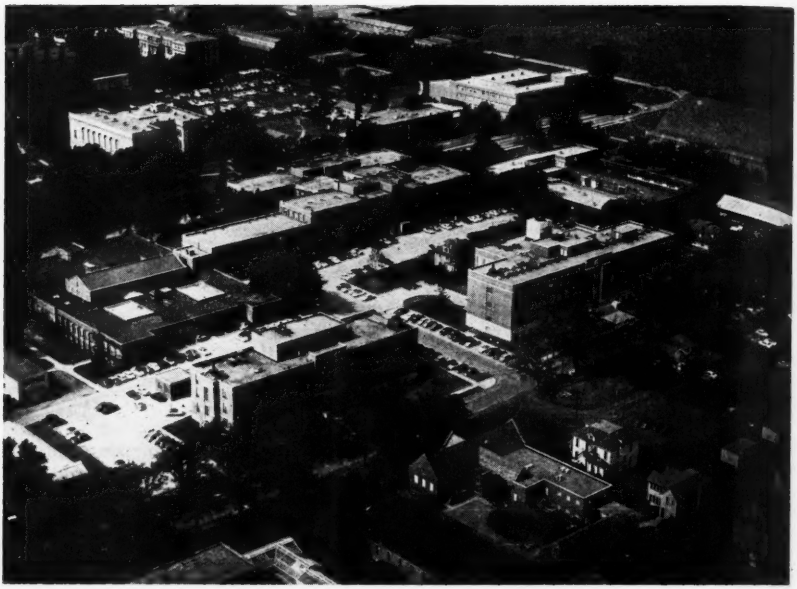
In May, 1947, the United States Atomic Energy Commission formally announced the location of one of its major research facilities at Ames, to be known as the Ames Laboratory, operating as an integral part of the Institute for Atomic Research. In return, the State of Iowa has leased certain building sites to the Commission.

Among the research programs of the Institute, which include those in chemistry, physics, metallurgy, and biology, engineering has three major phases.

Varied Programs

The chemical engineering division is concerned with the development of processes for producing from ores, compounds of uranium, thorium, zirconium, and other materials of special interest in nuclear reactors. Processes which have previously been carried out only in laboratory glassware are tried on a pilot-plant scale in engineering equipment before they are adopted for commercial production. Information obtained from pilot-plant operation is essential to economical design and efficient operation of a full-scale plant.

The basic chemical engineering unit operations that are important in development of processes of interest in the nuclear field, such as solvent extraction, are studied from a fundamental point of view. Treatment of by-product and waste materials from nuclear processes is also explored, and



The central group of this photograph includes major units of the Iowa State College Institute for Atomic Research and the Ames Laboratory of the Atomic Energy Commission. The two large rectangular structures in the foreground are the Metallurgy and Research Buildings of the Ames Laboratory. At left center is the Physics Building of the College, connected with the Chemistry Building by the Office and Laboratory Building of the Institute for Atomic Research. Above the Physics Building is the white mass of the College Library, with Marston Hall, headquarters of the Division of Engineering, at the upper edge of the photograph near the left. (This view is taken from the north-east.)

other fundamental research is being carried out which promises to be useful in the design of more compact nuclear reactors.

Research in ceramic engineering involves such problems as the fabrication of high-temperature crucibles and other ceramic bodies. Determinations of the basic properties of ceramic materials are also carried out with reference to such factors as vapor pressure and reactivity toward metals or other materials, including the gases of the surrounding atmosphere, either natural or artificial.

The program of the engineering development group includes the investigation of solid and fluid reactor materials and their behavior under load. Mechanical properties, such as strength, stiffness and hardness of materials of potential use in reactors are determined; facilities include equipment for conducting creep, impact, and fatigue tests. Cooperation with other engineering groups on special design problems is an additional activity of the development group.

Special laboratories have been constructed by the Institute, and courses

have been developed in the Division of Engineering to train graduate students in the basic techniques and principles required for the general field of nuclear engineering.

New Facilities

Four new and modern buildings have been completed; two of these, the Metallurgy and Research units, have been constructed by the Atomic Energy Commission on land leased from the College. The Metallurgy Building consists of four stories and contains about 45,000 square feet of working space. The Research Building has three floors above ground, a basement, and a sub-basement; it contains about 88,000 square feet of working space.

The other two buildings have been constructed by the College. A three-story Administration and Laboratory Building, connecting the Chemistry and Physics buildings, contains about 25,000 square feet of working space and houses the administrative offices of the Institute, special research laboratories used jointly by the chemistry and physics staffs, and a large physical sciences reading room. The Synchrotron Building contains the 70-million-volt synchrotron, together with excellently equipped research and control laboratories for nuclear studies in high energy radiations and for general research in electronics. This building has been erected on a 200-acre tract near the campus, set aside for special use by the Institute for Atomic Research.

The Institute will also continue to use many of the excellently equipped laboratories in the Physics and Chemistry buildings. Special mention should be made of the various calculating machines of the Iowa State College Statistical Laboratory available for the treatment of theoretical problems. In addition, the comprehensive College Library provides valuable assistance in the research program.

Welcome to ASEE

Members of ASEE visiting the Iowa State College for the Annual Meeting will find the Institute of unusual interest. Plans are presently being completed for guided tours of convention visitors through the buildings and laboratories. Details of these inspection arrangements will be available at the convention, both for the Station and the Institute.

Thanks are due to John H. Bolton, Editor of the Engineering Experiment Station, and to Ned Disque, Director of the Iowa State College Information Service, for supplying the materials and illustrations in this group of articles on the College.

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EDUCATIONAL AND RESEARCH PROBLEMS IN NUCLEAR METALLURGY

With Special Reference To Fuel Elements

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The problems confronting the metallurgist in the field of nuclear materials concern characteristics of the solid state, of gases and liquids, solutions, and interactions between solid, gaseous, and liquid phases. The main variant is temperature, and the practicality of nuclear reactors as heat sources is limited by temperature just as with conventional power plants. Ordinarily, desirable properties such as vapor pressure, corrosion resistance and strength of materials are affected adversely by temperature increases. Fortunately, the cost of nuclear fuel in a fully developed nuclear-power technology is expected to be a quarter to a third of conventional fuel costs, so that lower temperatures and efficiencies can be tolerated.

Nuclear reactors differ from conventional heat plants particularly in respect to diversity of types, limits on kinds of materials that may be used because of neutron economy considerations, the presence of neutron and gamma radiation, and the production of practically unlimited amounts of heat per unit volume. The development and production of suitable materials for the reactors built to date have taken an appreciable fraction of the effort of the engineers working in the nuclear energy field. While many problems have either been solved or avoided by use of lower temperatures, the field has only been surveyed and exploratory paths cut through. Most of the practical developments still lie in the future.

Even in the present state of power reactor development, the approach to presenting, coordinating, and interpreting the wealth of information already available in the nuclear field on fuel element metallurgy, corrosion, and coolants can only be that of the fundamental considerations of inorganic and physical chemistry, physical metallurgy, and physics, including an excellent knowledge of the solid state. Therefore, we believe that the student should be thoroughly familiar with these subjects before he attempts to specialize in the nuclear field, and that a thorough working knowledge of these fundamental subjects is more important than early specialization. The undergraduate course should include a course in atomic physics, with a brief introduction to nuclear physics. A detailed discussion of reactor physics is not needed.

The metallurgist should obtain a general familiarity with the basic engineering courses, including strength of materials, the elements of chemical engineering, electrical engineering,

and possibly of structures. Particular emphasis should be placed on hydrodynamics, heat flow, and heat transfer.

We believe there is little time for specialization in most undergraduate engineering curricula. It may be proper for some schools to carry out specialization in the nuclear field in the undergraduate course but most schools should not do so. Nuclear power is a field of endeavor more than a profession. In this respect it is similar to the field of petroleum technology. Some schools have courses in petroleum engineering but most colleges look upon it as a field requiring a broad background in fundamentals rather than specific professional training.

On the other hand, specialization in nuclear power engineering can be carried out in major graduate schools to the advantage of everyone. In fact, we strongly advise that a number of universities plan graduate curricula and undertake the task of developing good laboratories in the nuclear power field. We recommend, however, that even at the graduate level most institutions continue to stress basic fundamentals and principles rather than highly practical techniques. The objective of universities should be to teach engineers how to solve *all types of problems* rather than specific problems only. The engineer can specialize sufficiently after leaving the university.

The graduate curriculum for the nuclear metallurgist should include nuclear physics, advanced work in inorganic chemistry, solid state physics, and physical metallurgy. Emphasis should be placed on laboratory work in all of these fields.

The use of examples from the field of nuclear energy in illustrating and teaching fundamental principles is of course highly recommended at both the undergraduate and graduate levels. A number of examples that may be used in teaching are mentioned in the following paragraphs.

Fuel Element Metallurgy

The preparation of fuels and fertile materials in such form that they can be used in nuclear power reactors (whether as metal or oxide in heterogeneous reactors, or as a slurry or solution in homogeneous types), introduces almost every known problem in metallurgy. The mere listing would be too long for this paper.

Preparation of the oxide fuel elements involves ceramics, while the preparation of the solutions and slurries for homogeneous reactors introduces both physical and inorganic chemistry. Some of the important problems in this latter case include the formation of colloidal suspensions and the prevention of agglomeration or precipitation of particles under the peculiar conditions existing in homogeneous reactors. Solutions of salts in water, acids, or bases, fused salts, and liquid metal solutions are all under investigation.

A very large number of problems deal with the production of uranium and thorium. The ores are largely of low concentration and vary widely in composition. In this country, uranium ores frequently occur with vanadium; some are readily separated and concentrated, others are difficult. Thorium usually occurs with the rare earths, frequently as sands. The uranium and thorium oxides are concentrated and then purified by solvent extraction.

The production of pure uranium, thorium, beryllium, and zirconium illustrates the problems of dealing with metals high in the electromotive series, which are reduced by magnesium or calcium. The application of electrolysis to fused salts of these metals is suggested as a profitable research approach.

Uranium

Uranium should have an attraction for all metallurgists, and its peculiarities can certainly supply many examples for teaching the basic principles of metallurgy. Like thorium and zirconium, uranium is difficult to produce in the purity required for reactor use. As with aluminum, purification must be carried out before reduction. Uranium goes through phase changes at 660° and 770° C and is highly anisotropic below 660° C. It oxidizes rapidly under hot working, and develops preferred orientation during rolling or other processing in the alpha phase below 660° C. Wrought uranium undergoes dimensional changes when thermal cycled or under irradiation. Uranium may be stabilized by quenching from the beta phase, from about 725° C, to decrease preferred orientation. Grain size is likely to be increased by this treatment and some warping occurs.

Uranium responds well to alloying for grain size control and stabilization against warping, growth, or surface roughening due to thermal cycling and irradiation. Alloying and heat treatment can be used to increase the water corrosion resistance of uranium.

As a metal, thorium is respectable with a cubic lattice; it is readily worked but it has low water corrosion resistance and oxidizes readily in air.

Both thorium and uranium are somewhat hazardous as a result of their natural radioactivity, so rolling or shaping must be done on hooded or well-ventilated mills under the supervision of health physicists. However, the hazard is not great. It is expected that most power reactors will use thorium alloyed with uranium-233 or natural uranium alloyed with plutonium. These two fuels are extremely hazardous and the production of the alloys and all work on the metals must be carried out in completely sealed glove boxes or in extremely well ventilated hoods.

Plutonium which has been irradiated through several fuel cycles contains higher isotopes which fission spontaneously, with production of neutrons in dangerous amounts. Manufacture of fuel elements containing highly irradiated plutonium must, therefore, be carried out by completely remote operation.

Likewise, uranium 233 irradiated through several fuel cycles contains a small amount of uranium 232, this gradually decays to thorium 228, which emits gamma rays. Uranium 233 which has been freshly decontaminated of fission products and thorium can be handled in glove boxes. After a few months, however, completely remote operations are required.

Also, sufficient 228 builds up in the thorium after a few per cent burnout so that the combination must be handled remotely even though it has been completely freed of fission products.

Cladding

Cladding thorium and uranium introduces new problems. In the first place, a metallic bond between the cladding materials, such as aluminum,

zirconium, or stainless steel, and the fuel is desirable to obtain high heat transfer rates. Such a metallic bond introduces thermal stresses due to differences in expansion of the fuel and shell. While processes for cladding uranium with aluminum or zirconium have been developed, present methods are not completely satisfactory and better processes are needed. The use of liquid sodium or lead between the fuel and cladding is also feasible, and this eliminates stresses due to differences in thermal expansion of the two metals.

Another particularly difficult problem is that of sealing fuel-element cladding materials. Because the cladding must completely enclose the fuel, at some stage in the process high integrity closures in the cladding must be made by welding, pressure bonding, brazing, or similar methods.

For example, in roll cladding uranium plate with zirconium, not only must the zirconium be bonded to the uranium core, but the various zirconium components must be bonded to each other.

This requires that all facing or mating surfaces be kept clean while heating to temperature and during the rolling process. Such cleanliness is often achieved by placing the whole assembly in sealed and evacuated boxes.

Inspection

Inspection of fuel elements is carried out by non-destructive methods, using X-rays, eletronic devices, and high frequency sound waves. These procedures have been developed to the point that inclusions, minute holes, and other imperfections can be located in the fuel element cladding or in the bond between cladding and core. Inspection techniques are particularly valuable in fuel elements, since the entrance of high temperature water through a hole in the cladding of a fuel element results in rapid corrosion of the uranium or thorium core with swelling and breaking of the fuel element cladding. As a result fission products and plutonium, along with oxidized uranium, are spread throughout the reactor system. The reactor must then be shut down and the broken fuel element removed.

In use, the fuel element is subjected to a set of peculiar conditions which have no parallel in conventional power plants. For each atom of fuel fissioned, two new atoms are formed. These fission products are trapped in the crystal lattice of the fuel metal, causing a gradual increase in volume. The fission products fly apart with tremendous velocities and, as they are slowed down, heat the surrounding atoms. The heat production causes large temperature differences and high stresses in the fuel metal.

Burn-outs

One of the perennial problems is the development of uranium alloys to withstand burn-outs of one to two atoms per hundred atoms originally present. Metal fuel which is used in power reactors may produce up to perhaps 5×10^7 Btu/ft^3 hr, while boilers produce about 2×10^5 Btu/ft^3 hr. Under these conditions a power transient or power surge for a fraction of a second may melt the fuel elements. This permits the fuel and fuel cladding to react explosively with the cooling water, releasing radioactive fission products and uranium-233 or plutonium. For this reason, reactors are built in very heavy vessels or are

surrounded by thick concrete walls and placed in sealed buildings. Oxide or ceramic fuel elements with water or liquid-metal coolants such as sodium, greatly reduce the possibility of chemical reaction. Sodium which is vaporized and permitted to escape reacts with the oxygen of the air. It is impractical to design buildings to withstand a complete instantaneous sodium-oxygen reaction. Fortunately, however, the burning of liquid sodium in air, while seemingly rapid, actually is a surface combustion similar to that of a heavy oil which has low vapor pressure.

Use of ceramic fuel elements, again, introduces the problems of low thermal conductivity and very high fuel element central temperatures and thermal stresses along with low strength materials. Some of the metal alloys of interest are pyrophoric under certain conditions even at room temperature. Others, particularly those containing plutonium, are highly toxic.

Irradiation Damage

Irradiation damage to structural materials such as stainless steel, quenched steels, mild steels, and aluminum is of interest. In general, the damage is similar to work-hardening and is of little consequence in reactor design. The ductile-brittle transient temperature in steels is raised, but apparently not enough to approach practical operating temperatures. In the case of the quenched steels, the problem may be more serious since structural and property changes now unforeseen might occur in use while many test samples gave no signs of these changes. Much work remains to be done in this field.

Corrosion is, in general, the factor that limits coolant temperatures and thus the operating temperatures of water-cooled heterogeneous reactors. On the other hand, heat transfer and thermal stresses limit the rate of heat production in such reactors.

Corrosion Problems

The corrosion problems of particular interest in the heterogeneous reactor field are high-purity water-corrosion of aluminum, zirconium, and stainless steel. Corrosion in homogeneous reactors involves acid solutions and their attack on zirconium and stainless steels. The attack of liquid metals on aluminum, zirconium, stainless steels, and other structural or cladding materials is usually a solution effect rather than true corrosion. In some cases, grain boundary attack and selective removal of some components have been observed. Erosion combined with corrosion and dissolution is important in many applications, particularly in the attack of water and its solutions on aluminum and stainless steel.

An example of the use of basic knowledge of liquid-solid interactions is that of the study of aluminum corrosion. Aluminum corrodes rapidly and pits badly in ordinary water at temperatures as low as 100° C. The corrosion is much less severe in high-purity water. At temperatures high enough to give steam pressures of interest in the power industry, the corrosion rates are higher. Tests beginning during the war and extending to the present time have demonstrated that 2S Al may be used in high purity water at temperatures as high as 230° C. The water must be pure, however, with resistivity in the range of 10^5 to 10^6 ohms per cm. The rate

of flow must exceed about 8 ft/sec to prevent pitting caused by formation of various ions in static solutions. While corrosion rates are initially high, they decrease rapidly to acceptable rates in about two weeks by adherence of the hydrated oxide film. Addition of acid decreases the corrosion rate. At temperatures of about 275° C, the corrosion rate becomes high, and test samples disintegrate in a few hours regardless of the purity or pH of the water.

An examination of the corrosion mechanism in terms of the interfaces between the solid metal, its oxide film, and the liquid water phases indicated that the hydrogen emitted during the oxidation of the aluminum was diffusing into the metal and causing surface blisters. Prevention of the hydrogen penetration by use of nickel or copper alloys was possible, since these metals act as hydrogen cathodic centers and cause release of the hydrogen as molecules to the water. Tests indicate that aluminium alloys of this type may be usable as a fuel-cladding material for nuclear reactors in high-purity or slightly acidified high-purity water at temperatures up to 300° C.

The question of mass transport has required a complete theoretical investigation of how solid corrosion particles form in the cooling water and how they are deposited on active surfaces. This work made use of basic theoretical considerations to solve a very tough engineering problem. The corrosion resistance of zirconium is much higher than that of aluminum. Zirconium alloys have been developed that result in lower and more reliable corrosion rates than occur with pure zirconium.

The problems of coolants are intimately associated in many respects with corrosion. For example, when a metallic fuel element cladding fails and the coolant is water, the coolant will enter the hole in the fuel element and cause rapid corrosion of the uranium or thorium. Special alloys, as noted above, are able to reduce the rate of corrosion. However, corrosive fission products and uranium or thorium oxidation products will become mixed with the coolant and will be carried through the entire coolant system. The coolant cleanup method must be able to remove these fission products and any uranium-233 or plutonium present as well as the fuel.

Coolant Requirements

In homogeneous reactors the fuel is slurried with or dissolved in the coolant. In this case the requirements for the coolant are that the solution or slurry not precipitate or settle out, that the resultant liquid not be impossibly corrosive, and that leaks not be allowed to occur. Leaks are serious and hazardous in homogeneous reactor systems. Leak-proof systems including heat exchangers are complex and expensive. Cheaper, more easily repaired pumps, heat exchangers, and valves are needed.

Liquid metals and their handling involve additional problems. Heat transfer rates of 500,000 to 2,000,000 Btu/ft^2 hr using liquid metals and 300,000 to 1,000,000 using water are desirable in power reactors. High heat transfer rates are desirable in the heat exchangers, but because stainless steel is used, over-all coefficients of only 200 to 600 are finally obtained. Very large heat exchangers are therefore required.

Under normal operating conditions,

maintenance of the coolant in water-cooled heterogeneous reactors involves the removal of corrosion products by ion exchange and filtration, the separation and recombination or discharge of gaseous decomposition products, and the control or suppression of solid corrosion deposits on heat transfer surfaces. In case of fuel element failure, gaseous fission products and solid oxidized fuel particles must also be removed. Since all materials are radioactive, the system must be operated remotely, including handling the ion beds and filters.

In the case of sodium-cooled reactors, the sodium can be purified by cooling and passing over steel-wool filters to trap precipitated and insoluble materials. Special means must be provided in case of fuel element failure. The purification of homogeneous reactor coolant properly belongs in a discussion of fuel recovery and decontamination. In water slurry or solution reactors, water decomposition products must be continuously separated and recombined, while the gaseous fission products are separated and stored. Boiling-water reactors introduce other operational problems.

Gas coolants have been used at temperatures in the range of a few hundred degrees Centigrade. Future gas cooled reactors will be operated at temperatures of 650° C and higher, using helium or other gases. Ceramic fuel elements, alloys resistant to high temperatures, and special gas compressors and turbines must be developed before these reactors become practical. Gas turbine cycles combined with steam cycles promise higher thermal efficiencies than those of the most efficient conventional power plants in use today.

The problems mentioned above plus many others confront the educator when he considers how and what to teach in university courses. Obviously, it is impossible to discuss the details of the many ways in which these problems have been solved. Any practical solution of a problem is likely to be outdated before a student can finish his training. Further, the entire nuclear power field is in a state of flux with a general reduction of the theoretical aspects to practical applications.

What to Teach

This brings us to the only practical solution: to teach general fundamentals as mentioned earlier. The teaching of these fundamental principles, plus practical laboratory work of a general nature, is all that can be covered adequately in the undergraduate courses. The ideal procedure is to teach and demonstrate by student experiments what takes place, for example in rolling uranium as well as mild steels. The use of uranium along with steel and other materials will illustrate such phenomena as the effects of anisotropy on dimensions, the importance of folds, and trapping of inclusions. The unique properties of uranium should make it of general interest to students.

The use of uranium and zirconium to teach the basic methods of roll bonding is another example, as is the use of this same system for teaching the principles of cast-bonding and extrusion.

If it is desired to have graduate courses in the nuclear field, one certainly should be on nuclear materials and should include extensive laboratory work. An outline of the lectures in such a course follows:

Introduction to Reactor Materials (U, Th, Pu, Zr, Be, Ti)
Purification and Reduction to Metal
Melting and Casting
Fabrication of the Metals
Physical Metallurgy of the Metals (Including Textures, Alloying, Heat Treatment, Corrosion, Thermal Cycling, and Irradiation Effects)
Fuel Element Manufacture (Including Canning, Roll Bonding, Extrusion Cladding, Powdered Metallurgy, Ceramics)
Inspection and Testing
Behavior of Fuel Elements in Reactors (Including Clad Failures, Distortion, Burn-out)
Structural Materials (Al, Stainless Steel, Zr, Ti)
Liquid Metals (Na, K, Pb, Mg, Bi)
Development Procedures (Including Sample Irradiations and Prototype Fuel Element Tests)

The courses at the graduate level can be supplemented and extended by on-the-job and thesis training at one of the National Laboratories.

Knowledge Expected

A discussion of what Argonne National Laboratory expects in the men employed for development work in materials can be given quite briefly. Argonne has an extensive Metallurgy Division with a continuous requirement for well-trained men. It is desired that the men have an excellent knowledge of the fundamentals of physical chemistry, physics, and metallurgy, or training in ceramics, corrosion, and physics—particularly the solid state. A practical command of the equipment, procedures, and principles involved in metallurgical research and development is also helpful. Specific knowledge of the nuclear field is not a requirement though a broad understanding of the principles involved is highly desirable. Special facts will be picked up quickly on the job.

In summary, we would again like to emphasize teaching the fundamentals of physics, chemistry, and metallurgy, with laboratory experience and examples from the nuclear and other fields, as the undergraduate preparation for work in nuclear materials. A graduate course in nuclear materials should build on this fundamental knowledge and extend the metallurgist's experience in other fields, rather than simply specialize in nuclear materials. The metallurgist is expected to play a role in research and development, in manufacture of fuel elements and reactor components, and in the application of these materials to power plant operations. He must be able to face new problems daily and to apply fundamental knowledge in solving such problems.

Editorial Note: The article above is revised from an oral presentation, one of five at the session sponsored by the ASEE Committee on Atomic Energy Education (P. N. Powers, Chairman), at the Cleveland EJC Nuclear Engineering and Science Congress, December 14, 1955. Through the courtesy of the session co-chairmen, C. K. Beck and C. F. Bonilla, it is hoped to publish in the June issue the other immediately available paper of the group.

THE ENGINEERING TEACHER AND FIELD RESEARCH

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If research is defined as a critical and exhaustive investigation or experimentation, the aim of which is revision of accepted conclusions in the light of newly discovered facts, it is sometimes difficult to tell where laboratory research ends and field research begins. In general, however, it seems proper to say that field research is carried out on a finished product, structure, or part of a structure under actual conditions of normal use.

The following would be legitimate examples of field research: road testing of an automobile, flight testing of an airplane, a vibration analysis of a steam turbine, or an experimental determination of stresses caused by train loads on a completed railway bridge. Whether formally recognized or not, field research has played an extremely vital part in most technological advances, in improvement of basic design techniques, and in development of production and construction procedures.

Examples of Field Research

In civil engineering, many productive field research programs have been carried out, especially in soil mechanics. Need for such studies is very great, as theoretical progress in some phases of soil mechanics is now being impeded by lack of performance data on existing structures. In a 1945 article entitled "Shipways with Cellular Walls on a Marl Foundation," Terzaghi, Fitzhugh, and Miller explained the construction of some large piers. These were unique because the procedures and design were changed to conform with new data gathered during construction. Piezometers have also been used in hydraulic-fill dams to warn of unsafe neutral pressures in extremely poor foundation soils.

Such structures could not have been built with safety or reasonable economy, if at all, without careful research.

The anchored bulkhead is a steel-soil structure used to retain earth fills. It also cannot be studied by exact stress analysis techniques, and field research is of value in design and construction. In 1949, Professor Duke of UCLA conducted a comprehensive test program on an anchored bulkhead at Pier C in Long Beach Harbor, California. One of his most interesting findings was that settlement of the hydraulic fill caused a significant increase in stresses imposed on anchor rods. These loads were later relieved by digging through the fill and loosening the anchor rod turn-buckles. The increased stresses would undoubtedly have caused failure of the bulkhead had they not been detected by this field research.

In the same way, understanding of the actual consolidation process in

loaded soil has been greatly aided by careful field settlement measurement programs. Comparing the results of these field settlement measurements with those for laboratory settlement analysis has made possible greater accuracy and validity for laboratory methods.

Piles and Bridges

The way in which load is transferred from a bearing pile to the supporting soil is complicated greatly by the variable nature of different soils. Field tests have given much information regarding the actual nature of the load transfer, thus leading to more accurate design of bearing piles.

The common slab-and-beam highway bridge is a highly indeterminate structure and is normally designed by approximate methods. Field deflection and stress-measurement programs have aided greatly in understanding the behavior of these structures, again allowing more accurate design procedures. The same tests have given much information regarding "composite action," in which the concrete slab acts with the steel girders to form T-Beams.

Instrumentation

No effort has been made here to give all requirements for a successful field research program, but a few important ones can be mentioned. Where practical, all measurement procedures should be checked by independent methods, as SR–4 readings by a few Carlson or other types of strain gages. The simplest practical instrumentation should be used, designed for long life, wherever it is possible that long-time readings may be desired. Installations should be protected as much as possible, both from construction procedures and from the idly or maliciously curious. A thorough and complete diary, supplemented by photographs, is very useful in field research work and should be faithfully kept.

Objections to Field Research

In spite of the many advantages of field research, there are those who object to it for various reasons. As an example, contractors and construction engineers are primarily concerned with the *completion* of building, and are thus impatient with the field research engineer whose work occasionally slows down progress, or may demand changes in the usual erection procedures. Field research frequently furnishes information of value to the engineers and contractors, but it is sometimes difficult to convince them of this fact.

In addition to the resistance offered by the contractor and the engineer, carelessness or ignorance on the part of workmen often plays havoc with field research programs. For example, strain-meter leads have been cut by construction employees because these leads interfered in some way with their work. Field research men must be very careful to see that as many workers as possible understand what they have been doing. Success of the test work in no small way depends upon the good will and assistance of the contractor and his employees. Field research done completely apart from any other type of work is most desirable, of course, but is seldom possible.

Financing

Financing of field research is a question which always arises early, and it seems logical that financing

should be largely done by the party benefiting most from the results of the research. This might be a manufacturer, a producer of building materials, a builder, a contractor, or even an independent research engineer.

Field research is often done by graduate students or faculty members of colleges and universities working on actual projects. In this case, financing can conveniently be done, as by the University of California at Los Angeles, through a "Service-to-Industry Contract." Under this agreement, industry purchases instruments and finances the test installation, while university personnel design the system, obtain the data, and interpret the results. Unless the research projects are classified, the university holds publication rights, but makes confidential progress and final reports to the industry or other organization involved.

Value of Field Research

Productive field research must be done in accordance with sound, basic engineering principles. Being more broadly familiar with these principles than any other group, the teaching profession has a moral obligation to encourage and participate in field research. The field engineer and contractor, on the other hand, have a vital skill in practical judgment which the engineering teacher may not have had the opportunity to develop fully. Thus the engineering teacher benefits significantly from field research through having his theoretical knowledge tempered and amplified by experience in actual field design and construction techniques. Even more specific gains may be represented by the acquisition of first-hand information on field experimental stress analysis techniques.

Another very important benefit derived from responsible participation in an extensive field research program is a strong and lasting recognition of the extreme importance of careful, sustained, and integrated planning throughout the life of the research program. Such planning is useful to the success of any venture, but in successful field research it is vital. As a final note, it is of interest that engineering teachers sometimes get paid for field research work, and that good opportunities are usually provided for professional publications.

NOTE TO AUTHORS

Please see that your *name* (as you wish it printed) is on your manuscript, with your title and professional affiliation in enough detail to serve as a mailing address. Other introductory data such as presentation before the ASEE or other society, previous publication or adaptation, and divisional recommendation, are also most helpful. (This may sound silly, but manuscripts have been received without names, and usually lack all other facts.) Thanks for your cooperation!

CORPS OF ENGINEERS SUMMER STUDENT PROGRAM

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Engineering students who obtain summer work with an outside engineering organization have an excellent educational opportunity, and most college programs suggest that undergraduate study be supplemented in this way. If utilized properly, such experience enables students to see practical applications of topics covered in their classrooms; often the project work provides valuable background for courses not yet taken. Perhaps most important of all, vocational experience often demonstrates the usefulness of subjects previously considered of little worth. These changes in opinion or value judgments about academic material can open up whole new areas where previously little interest or effort was expended.

During the summer of 1955, the author participated in the Summer Student Training Program of the Kansas City District, Corps of Engineers, which had requested a careful examination of their program. A resumé of the study findings may be of help to faculty members who wish to evaluate the educational contribution of summer work programs. It will also make available specific data to assist counseling of students in regard to this or similar programs.

History and Administration

The Summer Student Training Program was originated to interest students in the Corps of Engineers as a career, to give training, and to help with the seasonal overload of subprofessional work characteristic of a large engineering organization. Aims have not been changed since the inception of the program as a casual procedure in 1939. In 1950 it began to be regarded more seriously, and expansion and formal organization were begun at a District level (Kansas City). In 1952 coordination was taken over at the Division level (Missouri River) and the program emerged into the Summer Student Training Program existing today.

Projects in the District are surveyed for openings early in the spring. Following the preliminary review, contacts are made with students during the regular interview trips to the local colleges; a second survey is then conducted to confirm the openings. Finally, commitments are made matching the interests and qualifications of the student to the job as fully as possible within the inherent limitations of the situation. Students selected early in their college careers are encouraged to return during subsequent summers, and are then given preference in assignments.

The students for this program are taken from many engineering curricula: aeronautical, mechanical, electrical, chemical, mining and metallurgy, mathematics and physics. Civil engineers are, however, much the

most numerous. Trainees are chosen primarily from students finishing their sophomore or junior year, although occasionally students are selected who have finished only one year. Shortly after the student starts to work he is called to the District Office (Kansas City) for a day of orientation. Then he returns to his assignment, where he works throughout the summer. The Division Office has directed that each student is to be assigned to at least two different types of work during the summer. This policy is implemented wherever possible.

Assignments of the students are varied. Several are placed in the drafting offices and various branches such as Hydrology, River Operations, Planning and Reports, and the Laboratory. The students work *with* and *for* engineers. As trainees, they are encouraged to ask questions and contribute ideas on current problems. Reference books and current articles are made available, especially in branch office assignments. There is opportunity for professional growth in all positions surveyed. The amount of opportunity made available depends considerably on the student's supervisor; how well the opportunity is used depends on the student himself.

Survey Method

The data for this study were secured from the trainees by two sets of questionnaires. One set was completed by the students at the beginning (23 responding) and one at the end (19 responding) of the summer of 1955. Sixteen pairs of matching questionnaires were obtained. As a validation and extension of the data collected by questionnaire, more than three-fourths of the students and their supervisors were then individually interviewed.

Discussion of Results

Work assignments of the students can be grouped conveniently under survey parties, drafting office, District branch office, and field office. Using this breakdown, an analysis is given in Table I showing the number of different types of tasks assigned the students, the number of courses they utilized from their curriculum, and the number of courses for which student value judgments were changed.

It should be noted that these results are given as reported by the students. This distinction is necessary because two important points were brought out in personal interviews with the students and inspection of their jobs. First, many of the students were not mature enough to derive much of the benefit available; second, the positions actually contained many elements classifiable under more course titles than the students reported.

A conclusion that can be drawn immediately from this table is that the best assignment for both quality and quantity of experience is one in a field office. It is also apparent that all job assignments in this program provide valuable background and experience for the participating students. The students report an average of 3.8 courses used in summer work.

Skills Transferred

An analysis of the transference of skill between the summer job and the school curriculum indicates that of the average 3.8 courses used in summer work, the most significant were mathematics, drawing, and surveying. A total of twenty-four separate course

titles are reported; these cover all the so-called basic subjects of the first two years, such as mathematics, physics, English, economics, and engineering materials.

Breaking down the course utilization by academic sessions shows that students finishing their junior year indicate only slightly more course work consistent with their job (average 4.5) than students who have completed their sophomore year (average 4.0). The fact that these figures are very close shows that the work done draws most heavily on the basic courses taken in the first two years. These data correlate with the part basic subjects play in the changes of value judgments, and transference of skills.

An analysis of course utilization on the basis of curriculum indicates a high degree of consistency between school work and experience for civil, agricultural-flood control, mining and metallurgy, mechanical engineering, mathematics and physics majors; a low degree of consistency is indicated for chemical, aeronautical, and electrical engineers.

Value Changes

At the end of the summer the students were asked to list those courses that had proved more important than previous estimates would have indicated. The overall average change in value judgment is 1.1 courses. Students working their first summer in the program show an average change of 1.5 courses, compared to 0.2 courses for students who have worked in the program previous summers. Table I shows those first year students who worked in a field office have the highest change in value judgment (average 4.5 courses) compared to all other first year groups; the drafting group has the lowest change (average 0.8 courses). The field office and District branch office groups show an intermediate change (average 1.0 courses). More than half of the courses mentioned in response to this question can be considered basic subjects.

TABLE I

Relation of Assigned Tasks To Student Opinions

	Field Office	Branch Office	Survey Party	Drafting Office
Average number of different tasks assigned	4.0	3.6	1.0**	1.0*
Average number of courses in curriculum utilized	5.0	3.0	2.0	3.5
Average number of changes in value judgments of students in first year of program	4.5	1.0	1.0	0.8

* Students report variation in type of drawing done.
** Students report some rotation of jobs within the survey parties.

Psychic Effects

A comparison of the responses to questions dealing with the "psychic income" aspects of jobs, asked at the beginning and end of the summer, shows that the effect of the summer job was primarily to reinforce original opinion. The students were asked to rearrange, according to importance, the following items:

a. Recognition
b. Security
c. Salary
d. Power
e. Respect
f. Health and safety
g. Variety of tasks
h. Social satisfaction
i. Self expression
j. Chance for advancement

The three items that were consistently noted as most important on both questionnaires are "chance for advancement" first, with "security" and "salary" indistinguishable as second and third. "Power" is the lowest ranking item on both questionnaires. Other items of minor importance are "satisfaction" and "health and safety." The students clearly indicate "respect" more important on the final than on the initial questionnaires.

Students were asked at the beginning and at the end of the summer whether they intended to work with the Corps of Engineers as a permanent career in the future. Based on the answers and supporting information available from both interview and questionnaire, the program did not appreciably influence trainees either positively or negatively toward the Corps of Engineers as a vocational goal.

It is interesting to note that the average age of the group not interested in a permanent job with the Corps is 19.5 years, compared to an average of 20.9 years for the "undecided" group, and 23.7 years for the "interested" group. This may be significant and invites speculation.

Summary

From the point of view of the participating student, the Summer Student Training Program of the Corps of Engineers is successful. This success may be judged in terms of four considerations.

1. In general, the students receive intensive experience in fields covered by several of the courses in their curriculum. In some cases the students receive wider training, involving experience in areas covered by as many as six or eight courses.

2. The new skills the students learn are to their advantage. Most of the trainees are not mature enough, however, to take full advantage of available experience or opportunities to gain new skills.

3. Students' changes in value judgments about courses in the curricula can be a significant advantage.

4. The psychic factors relating to the vocational goals of the students underwent reinforcement as a result of work experience.

From the point of view of the Corps of Engineers, the Summer Student Training Program meets its goals with only limited success.

1. The return to the Corps on their dollar invested in student labor is good. This opinion is expressed by the supervisors for whom the students work. Were this the only consideration, the program would be justified.

2. The benefits the Corps desires in the field of engineering recruitment are not presently being obtained by this program; there appear, however, to be no negative effects on engineering recruitment.

3. The country as a whole benefits by the training the Corps of Engineers gives the engineering students, whether or not the students choose a career in the Corps.

Major Advantages

Perhaps the most important advantage to the students of this or similar programs is not open to objective analysis. It is the opportunity for personal experience that the students gain by working with practicing engineers. Personal experience is the only way for students to find out what being an engineer actually means. By questioning these men, many of whom are authorities in their field, students can learn much that will help with their own professional development. Finally, in programs of this type, students learn to practice patience, accuracy and thoroughness—the primary tools of an engineer, and highly desirable additions to the standard curricula in engineering.

MIT School for Advanced Study

The establishment of a School for Advanced Study as an integral part of MIT's organization was announced January 4, 1956, by Dr. James R. Killian, President, Massachusetts Institute of Technology. The new school will provide means by which post-doctoral scholars from all over the world can join the MIT faculty in high-level theoretical studies and research. Professor Martin J. Buerger, former Chairman of the Faculty, has been appointed Director and Institute Professor, effective July 1, 1956.

"The advance in knowledge makes it increasingly important for scholars to pursue advanced study beyond the level of the graduate school and doctor's degree," Dr. Killian pointed out further. "In fact, the advancement of American science particularly requires more post-doctoral study and research in educational institutions.

"In its initial embodiment the school will be simply an organizational entity, but we hope ultimately to provide a center and adequate housing for fellows and guests and by this means to gain the advantage of cross-stimulation of ideas which occurs when learned and ingenious men are brought together in close social contact."

Scholars who are invited to MIT for advanced study will have the status of "fellows" in the school. This year there have been approximately 100 such people from fifteen countries studying at the Institute and they have been registered as "guests" or "visiting fellows."

Dr. Buerger added this comment, "We welcome such scholars and believe we can be of greater help to them by establishing the new school. Much can be gained in science and engineering through the interchange of ideas. Close association and intimate discussion between men in the same field of research, or in different fields, can produce new insights."

UNESCO and ASEE

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The writer represented the American Society for Engineering Education at the Fifth National Conference of the U. S. National Commission for UNESCO (United Nations Educational, Scientific and Cultural Organization) at Cincinnati, Ohio, November 3–5, 1955. Along with the many other organizations designated to nominate members to the National Commission, ASEE may well play a significant part in UNESCO affairs. For this reason the Secretary of ASEE asked that the Society membership be informed, through an article in the JOURNAL, of the aims, activities and accomplishments of UNESCO.

Objectives and Accomplishments

UNESCO is one of the specialized agencies of the United Nations. Its avowed objective is to contribute to world peace and security by promoting collaboration among nations through education, science, and culture. An underlying premise of its constitution is that "since wars begin in the minds of men, it is in the minds of men that the defenses of peace must be constructed."

The activities of UNESCO are international in scope and cover a broad field of direct aid to member states. An important contribution in the field of science and world understanding was the establishment, during the past five years, of a European Center for Nuclear Research (CERN) at Geneva, Switzerland. CERN was the outgrowth of an idea originally proposed by an American delegate to a conference in Florence, Italy, in 1950. UNESCO guided the undertaking from conception to completion. Exhaustive legal studies by UNESCO's Secretariat and copious exchanges of views finally culminated in the signing of a treaty on the project, at UNESCO House in Paris, by representatives of twelve European governments on July 1, 1953. The cornerstone of the main building was laid on June 10, 1955. All the governments are sharing the cost of construction, equipment, and administration, estimated at about $28,000,000 for the first seven years. UNESCO's outlay was a modest $25,000 over a three-year period.

This project is typical of many in which UNESCO plays the role of promoter, and it helps us to understand why the agency can operate on an annual budget of only $10,000,000.

No complete account can be given here of UNESCO's extensive program of aid to the less developed areas of the world. Assistance is provided in the establishment of museums, libraries and scientific laboratories; in the improvement of school and university education; in the preservation of art and historical materials; and in many other fields devoted to economic and social development. Such assistance enabled India to open its first modern public library in New Delhi, and Egypt to found at Sirs el Layyan an education center for the Arab States.

Some Current Plans

UNESCO is now grappling with grave economic and social problems peculiar to the vast arid zones of the Middle East and South Asia. It is also struggling to increase mutual understanding among nations through a global spread of both Eastern and Western cultures. No small part of this project is the supplying of good reading materials for new literates educated under the leadership of UNESCO.

Another project is closer to home. This concerns education in Latin America. The ultimate objective is the extension of free and compulsory education in all the independent nations south of the Rio Grande. Existing laws provide for such education in all these countries, but little has ever been done to implement or to enforce them. Plans call for the project to be launched in 1957, after a joint regional conference of UNESCO and the Organization of American States in Lima, during April of 1956.

The United States National Commission

The United States National Commission for UNESCO represents this country in the world organization. At the head of UNESCO is the Director General, with headquarters at the Secretariat in Paris, France. The U. S. National Commission consists of 100 appointed members, of whom 60 are in non-governmental organizations, 25 are representatives of Federal, state and local governments, and 15 are appointed at large by the Secretary of State.

The Commission is required under Public Law 565 (79th Congress) to call general conferences for the discussion of matters relating to the activities of UNESCO, "to which conferences organized bodies actively interested in such matters shall be invited to send representatives. . . ." Conferences have been held as follows: Philadelphia, March 1947; Cleveland, March, 1949; New York City, January, 1952; Minneapolis, September, 1953; and Cincinnati, November, 1955.

The Cincinnati Conference

The theme of the Cincinnati conference was *The First Nine Years—An American Appraisal and Forecast.* Including visitors from foreign countries, total attendance was approximately 1000, of whom about 800 were official delegates of organized bodies like the ASEE. Besides four plenary sessions, there were meetings of 17 smaller work groups averaging 40 to 50 delegates each. With slight changes in wording for clearer understanding, topics for open discussion by these groups were as follows: Basic Knowledge for Better Living; Meeting the Need for Free and Compulsory Education; Mutual International Understanding through Schools; The Role of the College and the University in Advancing Mutual Understanding; Mutual Understanding through Adult Education; Religion and International Understanding; Cultural Institutions; The Gift Coupon Program; America's Million Ambassadors (tourists, exchange persons); Man against the Desert; Human Problems and Technical Change; Human Relations; Breaking the Language Barrier; Music —a Universal Language; The Dramatic Arts and Mutual Understanding; Visual Arts in the Creation of Peace; Increasing Communication among Peoples.

Delegates attended group meetings of their own choice. As a representative of ASEE, the writer affiliated himself with the group which discussed The Role of the College and the University in Advancing Mutual Understanding. It soon became clear that institutions of higher learning differ widely in the extent of their participation in the affairs of UNESCO. Many do little or nothing that is directly traceable to planned cooperative effort. This situation apparently stems from inadequacy of communication between UNESCO and the colleges and universities. Accordingly, the group passed a resolution that the educational members of the U. S. National Commission be asked to convene a major conference to advance the interrelationship between UNESCO and American institutions of higher education.

It was suggested that UNESCO Student-Faculty Organizations be established in all colleges and universities and that closer cooperation be sought with the International Universities Association. UNESCO representatives on college campuses were urged to take the initiative in strengthening programs dealing with international relations and to solicit administrative encouragement and support.

Participation of Societies

A recent venture of the American Association for the Advancement of Science is indicative of the way educational, scientific, and cultural societies can contribute to the fulfillment of UNESCO objectives. The UNESCO Arid Zone Program contemplated for the Middle East and South Asia was recognized as having deep potential significance for the United States. Vast regions of our West and Southwest are arid or semi-arid. Realizing that the problems of these areas affect the welfare of the nation as a whole, the Southwestern and Rocky Mountain Divisions of the AAAS and the national parent society organized an International Symposium and Conference on Arid Lands in New Mexico. This conference was held in Albuquerque in the summer of 1955. Enthusiastic and vigorous support was given by UNESCO through immediate inauguration of plans to expand its arid zone program. It was reported at the Cincinnati meeting that efforts were being made to form a United States Commission on Problems of Arid Lands. The AAAS is to be commended for its initiative and resourcefulness in generating action on a program of such paramount importance to the United States of America.

Conclusion

The ASEE, through its representative to UNESCO and with the cooperation of Society members who have served as consultants in several foreign countries, should keep constantly alert to the needs of UNESCO in the advancement of educational, scientific, and cultural relations among the peoples of the world in the cause of peace and security.

THE PLACE OF SPONSORED RESEARCH IN THE ENGINEERING COLLEGE

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A paper presented at the Southeastern Section meeting, ASEE at Knoxville, Tennessee, April 15, 1955

In university circles there are few topics under more active discussion than the relation of sponsored research programs to the educational process. This is an understandable topic of concern because, the current costs of engineering and research programs being as high as they are, it is only through outside sponsorship that most educational institutions are able to make significant contributions. Also, because the largest portion of sponsored research is carried on in engineering colleges, we necessarily set the standards for such contracts, and the indirect effects of our actions on our colleagues in other colleges must not be overlooked.

About certain questions we are, of course, in basic agreement. We all assert that no research program should be accepted which in any way violates our fundamental purpose of preparing students to be good citizens and leaders in an economic and political future which promises to depend more and more upon technology. If our educational institutions succumb to commercial pressures or to desire for selfglorification, we can hardly expect our students to have the proper incentive for service to others, without which our civilization may not survive. On the other hand, we all know that if we cannot keep our financial books in balance, if we cannot maintain staffs of high quality, or if we fail to produce as well as disseminate new ideas, we are equally doomed to failure, either individually or collectively.

Beyond these points, however, our discussion often takes on the sharp tone of a debate over the merits of "research versus teaching" and argument as to which of these is the more important, particularly for the advancement of the individual teacher. Such debates are generally inconclusive and unproductive. They do indicate, however, necessity for defining closely the objectives of any research program in an educational institution. In so defining, it is essential to be perfectly honest. I stress this point because there are strong temptations to voice certain considerations but, perhaps unconsciously, to be influenced by others.

Research Objectives

Defining objectives for sponsored research programs is further important because, quite naturally, the objectives of the sponsor and the college often are not identical. For effective and continuing relations, the objectives of the two need to be brought into harmony but not necessarily into coincidence. A difference in objectives

does not itself imply the impossibility of, or even major difficulty in, working out programs to the mutual benefit of both parties, any more than the different interests of buyer and seller in normal commercial transactions prevent the negotiation of contracts advantageous to both.

Let us enumerate some of the objectives which may influence the development of a research program. Not all will apply to each institution; some are obviously more important than others; some can be advanced openly, while others are only implied; some will be more applicable to publicly-supported institutions, and some to private colleges. If you search your mind you can add others. Here is a partial list of good and bad objectives of research programs in an engineering college.

1. Advance fundamental knowledge in both analysis and synthesis
2. Support graduate theses
3. Give financial aid to graduate students
4. Increase vitality of teaching staff, both undergraduate and graduate
5. Assist industry in the geographical area to which the educational institution owes an obligation
6. Support the military needs of the nation in research and development
7. Supply services which the intellectual resources and physical facilities of the institution are uniquely capable of providing
8. Develop additional special competencies of the institution in important technical areas
9. Increase the prestige of the institution
10. Stimulate interdisciplinary programs
11. Provide services to individual companies to place them in a better competitive position within their industry
12. Provide services to trade groups to enable them to give improved service or to compete more effectively
13. Obtain funds to support other research programs within the college or university
14. Develop better laboratory facilities for the institution and nation
15. Give staff and students experience in solving actual engineering problems
16. Obtain funds to support other educational programs
17. Keep professors happy
18. Provide supplementary remuneration for staff members as a means of competing with industry or other institutions
19. Keep up with the Joneses

Naturally the items above are not entirely distinct, and indeed may overlap considerably. So much has been said about all of them that their implications are almost obvious; some will appeal to one group, some to another, and some will even arouse feelings of revulsion and will be discarded. Some are of primary benefit to an educational institution, others to a sponsor, while many contribute to the general welfare of the nation. However, I do not have the wisdom to assure you that any one of them (even the last) should be eliminated in every college. Although some may appear to be directed selfishly toward improving the position of the educational institution, they need the open-minded consideration of the sponsor if the vigor of our colleges is to be maintained.

As has been indicated, the college objectives must necessarily be related to the needs of the sponsors. A general classification of the sponsors and

a few specific examples are given in Table I below.

It is obvious that different objectives given earlier will appeal to different types of sponsors as they are shown here. After (and only after) it has selected its objectives from a list such as appears above, each institution must negotiate with the appropriate sponsors suggested below. For example, a state university might decide it should assist the industry of its state. It should first study the needs of the state.

There may be a dominant industry with an active and progressive trade

TABLE I

CLASSIFICATION OF PRINCIPAL AVAILABLE SPONSORS FOR ENGINEERING COLLEGE RESEARCH

General Class	Sub-Class		Typical Examples
Industry	Manufacturing Companies	Large	General Electric
		Small	Company X-Hairclip Mfg.
	Utilities		Edison Research Comm.
	Trade Associations		Portland Cement Assn. Amer. Railroads Enamel Mfrs. Warm Air Heating Boiler and Radiator Mfrs.
Government	Military	General	ONR OOR OSR–ARDC
		Operating	Signal Corps Wright Field Bureau of Ships
	National Science Foundation		
	Atomic Energy Commission		
	Non-Military Service Agencies		Bur. Public Health National Bur. Stds. Public Roads NACA
	State and Municipal Agencies		
Nonprofit Organizations	Operating		Battelle Memorial Mellon Institute
	Technical Societies		
	Fund Administrations		Engineering Foundation Industrial Foundations Carnegie Foundation

association. In such a case the development of sponsorship is easy, but the institution should guard against overspecialization. If the industry of the state is diverse, it is probably better for the institution to forego the objective of direct assistance to industry and decide to devote itself primarily to a fundamental program of broad interest which can be sponsored on a national basis.

Small industries do not in general feel they are financially able to support basic research, but they can provide faculty members with valuable experience in the solution of complex practical engineering problems. On the other hand, research agencies of the Department of Defense are receptive to proposals for basic research when such programs parallel the agency objectives, and the National Science Foundation is interested *only* in basic endeavors.

Recently, because of the tax situation, some of the larger companies have been setting up their own nonprofit foundations, to which they can contribute near the end of the fiscal year when their profit position is known, and for which contributions they can receive appropriate tax deductions. This mechanism allows them to dispense grants throughout the year. After appropriate examination and consideration, each foundation selects an area in which it wishes to provide support and establishes particular objectives with which it is in sympathy. Such foundations appear to be growing in number, financial resources, and interest in engineering research or education.

Many interconnections are possible between objectives and sponsors; I leave you to explore this fertile field. I need not warn you that, just as is the case with the electron-orbits about the nucleus of an atom, there are forbidden transitions. The application of good common sense will assure an economy of effort in enlisting the support of an appropriate sponsor who will be in harmony with your objectives.

Educational Teamwork Desirable

Still another factor needs attention. It is now well recognized that in the education of engineers there must be teamwork between the college on the one hand and industrial or governmental employers on the other. The college must do what it can do best, that is, teach fundamental principles, develop the ability to tackle hard problems by basic methods of approach, and cultivate intellectual habits and abilities which will carry the engineer successfully through a career where intellectual vigor is essential. Particular examples of engineering practice taught in the university are justified only as illustrations of general principles and methods of approach.

Industry, on the other hand, must assume the major responsibility for instruction concerned with arts or "practice," with the mature development of judgment underlying particular company methods, and for education leading to increased responsibilities.

In the broad area of research it also seems desirable that a similar division of labor should be made. The engineering college should pioneer in the exploration of the fundamental areas, because this is a natural complement to its teaching functions. The development of specific "hardware" should be delegated largely to industry. An exception to the emphasis on basic

research as opposed to hardware development might be made when, as a result of work in more fundamental areas, a faculty member conceives of a new device or devices, the development of which he naturally wishes to pursue himself. Another exception must be made when, because of military needs, the brain power of the universities should be utilized without depleting these resources by transplanting them to governmental or industrial laboratories.

Interdisciplinary Projects

One of the most productive areas for engineering research lies in interdisciplinary investigations, where the resources of a university give opportunities seldom duplicated in industry. Teamwork with psychologists, physiologists, biologists, and physicians illustrate the combinations by which we can make major contributions. It should be recognized, too, that engineering is now responsible for much of the continued development of what has been referred to as the fields covered by classical physics.

One of the most serious problems that have arisen, largely as a result of sponsored research, is the arbitrary division which is common in many of our colleges between the research and teaching functions and staff. This has probably been the result of historical development and economic forces. At the turn of the century, engineering colleges had research functions and operations quite similar to those of the Colleges of Liberal Arts, where each professor was expected to, and generally did, do a certain amount of research as a supplement to his teaching. At that time, costs of equipment were moderate, and the laboratory facilities used in teaching were generally adequate to support the relatively simple research needs of the day. As costs began to increase, however, a teacher who wished to do research often had to spend as much time selecting a project whose equipment needs were simple, as he did to the investigation itself.

Two solutions to this problem developed slowly for several decades before World War II:

1. Engineering Experiment Stations emerged, largely in state institutions, with specific budgets covering both personnel and equipment for long term efforts, and
2. Sponsored research expanded steadily, also with specific budgets, but normally of limited time duration.

The concept of the Experiment Stations was largely one of service to the geographical area supporting the institution, and there was some urgency to produce results which would be recognized by and generate support from the political body supplying the funds. In contrast, sponsored research was largely supported by industry. Funds from individual companies were usually applied to the solution of specific problems. Again there was a sense of urgency which prevented the laying of a broad foundation of fundamental knowledge. The trade associations which began to come into the field, on the other hand, were often interested in longer range developments and also in finding particular individuals who would devote most, if not all of their time to the interests of the supporting agency.

These appear to have been the major sources of support for engineering research in colleges before World War II; even then the funds available were very limited. Concurrently, the larger

industrial organizations were building up research organizations of their own, devoted primarily to the search for new products, but also at times supporting fundamental research which produced results of importance, in general outstripping those of the engineering colleges.

Examples of such basic research were the Davisson-Germer experiment at the Bell Telephone Laboratories, which gave experimental confirmation to the wave nature of electrons, and the work of Langmuir at General Electric in such diverse fields as electron emission, soap films, and cloud seeding. Under these conditions, many college professors who were not supported for a major portion of their time by Experiment Stations or industrially-sponsored programs became discouraged. They doubted the possibility of doing anything really effective, and devoted themselves exclusively to teaching, allowing their research abilities to atrophy.

Thus all the means developed for research support tended to separate the functions of teaching and research in the engineering colleges, a development which did not occur in the arts or pure sciences. We seem to have justified the statement that we never get a final solution to our problems; we can only hope for a relief from the last solution.

During World War II, military demands required the development of new research centers to solve not only the scientific, but also the engineering problems involved in the search for new and improved weapons. When teaching needs were reduced, and funds for research were unlimited, the professors of the country represented a personnel depository which could be used to meet our expanded research and development requirements. Under these conditions two things happened, and we might as well admit them:

1. The new research organizations set up in educational institutions to do creative engineering work were largely manned and almost entirely directed by physicists who, in the previous decades, had combined teaching with fundamental research.

2. Engineering teachers took leaves from the universities and went into industrial research under the direction of experienced administrators.

Frankly, I do not think that engineering education was ready for the leadership which it had the opportunity—but not the preparation—to assume.

Following the War, the Congress and government agencies recognized the need for the greatly expanded research program necessary to preserve our way of life. Again, as larger sums became available, and as manpower remained in short supply, there was a tendency to return to the old system of division into

1. A staff largely responsible for teaching, and

2. A separate staff for research, with some limited responsibilities in graduate teaching.

I believe the major problem of the next decade is that of finding out how to use sponsorship of research by both governmental and industrial organizations to develop an integrated program of research and teaching in which each effort supports the other. Perhaps to do this we need a broader definition of "research" in the engineering field. For example, at Illinois we have a program in which the engi-

neering college is actively developing improved teaching of mathematics at the high school level. I consider that the individuals participating in this program are definitely active in research—a research effort which we hope will attract industrial support because of its overall importance to industry. Of course, we must recognize that some professors can make their major contribution in teaching, while others make it in research. I hope that more members of engineering faculties will combine teaching with research, so that they do not identify themselves as either teachers purely or research workers solely.

Freedom in Research

One of the major attractions in an academic life has been the freedom to select one's own work. A university professor comes closer to being his own boss than any other individual. He normally chooses his general area of teaching, and, aside from meeting his classes, directs most of his own working hours. This is not a responsibility which can be entrusted to the lazy, so laziness is a major crime for a professor, a violation of trust which cannot be condoned.

There is some danger that, in accepting research contracts, we may feel it necessary to bring into the atmosphere of the university a miniature model of industrial organization, which, even if it does not include time clocks, introduces the time-clock attitude. This should be guarded against as the plague. Particularly, there should not be one set of rules for the teaching staff and another for the research staff, or their separation becomes automatic. This is not an easy problem to solve, especially because research programs involve extensive use of mechanics, stenographers, and other workers who must, or wish to, observe time schedules.

Research laboratories in industry are devoting serious attention to the problems of developing an atmosphere more like that of academic institutions. Let us not lose one of our major assets by slipping in the opposite direction and becoming too industry-like ourselves. For example, any sponsored research (other than military) which limits the right of a professor to publish should certainly be questioned seriously.

Furthermore, I do not believe it desirable to go out and secure a project and then come back and look for a professor to conduct it, or worse yet, assign a staff member to direct it. The initial formulation of the research program should start with the professor and the educational institution, not with the sponsor.

Solving our problems will require careful interpretation of them to our sponsors and potential sponsors, both industrial and governmental. It will also require more emphasis on certain objectives and the elimination of others. I will leave you individually to select those objectives you deem most important for your own institution, and to develop harmonious relations with sponsors which will further those objectives.

VEREIN DEUTSCHER INGENIEURE CENTENARY CELEBRATION

Program May 12-15, 1956, Berlin, Germany

Saturday, May 12

Addresses on: The relations of natural science and technology
Technological trends

RESEARCH AND DEVELOPMENT:

Power problems, with particular emphasis on atomic fission
Influence of the material on the development of processing techniques

DESIGN AND CONSTRUCTION:

The experiment as a basis for the design
Lightweight construction
Beauty of form

Sunday, May 13

Formal address on: Man and his technology
Festival performance in the "Schiller-theatre"

Monday, May 14

Addresses on: Social effects of technology
The law of survival

MANUFACTURE:

Principles of fabrication
Materials handling

MAN AND ECONOMY:

Future leadership
The engineer and the distribution of goods
Industrial legal protection

EXTRA-CURRICULAR ACTIVITIES FOR PROFESSIONAL DEVELOPMENT

JOSEPH F. ZIMMERMAN

Assistant Professor
Department of Economics, Government, and Business
Worcester Polytechnic Institute
Worcester, Massachusetts

Extra-curricular activities can be a valuable adjunct to the formal educational process. Although this conclusion has been and will be challenged by many educators, evidence will be offered to support it. The positive contribution of a well-balanced and well-rounded program of extra-curricular activities to the professional development of engineering students has neither been fully recognized nor exploited. Surveys reveal that many graduates of engineering colleges are promoted to managerial positions.

This prompts a question: Does the average engineering curriculum adequately prepare these young men for managerial positions? The answer generally is "no." Obviously, technical competence is not synonomous with managerial competence. Various management courses are offered at some engineering colleges, but these courses suffer from two limitations. First, only a limited amount of time can be devoted to such courses in an engineering curriculum. Second, no matter how realistically presented, such courses are still academic. Relatively little practical experience in dealing with people can be gained in the classroom. To a limited extent, however, this experience *can* be gained through a program of extra-curricular activities in which most students participate.

In presenting the case for extra-curricular activities one often encounters the argument that extra-curricular activities reduce the amount of time students can devote to their studies. It is well to call to mind the old proverb "All work and no play makes Jack a dull boy." Psychological investigations have demonstrated that a break from studies providing a little relaxation can lead to more efficient functioning of the mind. Furthermore, the time students would devote to a well-balanced program of extra-curricular activities often has been wasted in the past by "shooting the breeze," seeing movies, or drinking coffee. Many more students could participate in extra-curricular activities without reducing their study time by spending less time in "bull sessions."

Managerial Skills

A few of the more important managerial skills that can be acquired and sharpened by participation in extra-sharpened by participation in extracurricular activities are covered below:

1. *Cooperation.* The importance of the ability to cooperate and work with others cannot be overestimated. Successful management is based upon cooperation. Without it no organization can function effectively. A man will not be a successful manager unless he knows people and also their

idiosyncrasies. Experience in cooperation and working with others gained through extra-curricular activities can prove valuable when one moves into both the managerial and professional ranks. Perhaps this is the greatest value of extra-curricular activities.

2. *Initiative.* The most successful engineers and managers are men with initiative. They are the ones who inaugurate new programs or create new policies. Our economic system is generally competitive. Each business firm is attempting to get the jump on its competitors. Each firm is seeking men with ideas—with initiative. Extra-curricular activities require initiative on the part of the students. New ideas, new courses of action for the yearbook, debates, or dances are thought up and implemented each year.

3. *Leadership.* There is no substitute for experience. This is particularly true in the case of leadership. Extra-curricular activities provide an excellent training ground for leadership. Young executives customarily are urged or required to participate in community affairs. Charity campaigns, youth movements, church work, service club leadership, public affairs and civic speaking engagements are activities that most young men moving into managerial ranks are pressed to join. Where else in college, other than in extra-curricular activities, do students have the opportunity to gain leadership experience? Such experience is seldom available in the classroom.

4. *Decisiveness.* Decisiveness is another key characteristic of the good manager. Extra-curricular activities provide opportunities for students to gain experience in decision-making. To increase this value, however, the administrations of some of our colleges must recognize the maturity of their students and give them a freer hand in running student organizations. Often students are not permitted to take the initiative in running their organizations or are not allowed to make decisions that they, rather than the administration, should make. After graduation, students will not have college administrators readily available to make or deny decisions for them. Decisiveness is a trait lacking in many managers. Students cannot be expected to develop and sharpen this managerial skill unless they are afforded the opportunity by the administration of the college.

5. *Judgment.* Closely related to decisiveness is judgment as to people and situations. Successful men usually attribute their success to good judgment. Competent managers are able to "size up" other men as well as situations. They use good judgment in hiring and assigning employees. Sound judgment is essential to the success of a business firm in our competitive society. Should a new product be introduced? If so, when? Should plant expansion be undertaken? Should Jones be transferred or promoted? These are typical of the questions that require careful consideration. The opportunities which extra-curricular activities afford students to exercise this kind of talent are many.

6. *Effective Expression.* Engineers are notoriously poor at expressing themselves, either orally or in writing. The number of technical writers employed in industry and the number of communications courses incorporated in training programs for young engineers employed by large corporations are proofs of this charge. Opportunities are afforded by extra-curricular

activities to develop and practice effective speech and writing. Campus newspapers and yearbooks offer rare opportunities for students who have trouble writing effectively.

7. *Character Development.* This is an intangible, but of greatest importance. A sense of responsibility and an elevated code of values can be engendered through extra-curricular activities as well as in the classroom. Unfortunately, character development too often is neglected. All too commonly, students fix their sights solely on the material things of life. Unless they realize there is more to life than material things, they are in for keen disappointment later on. Also, our society will suffer if many of our young men, who in the near future will be leaders, are materialistic-minded, or fail to develop their ethical and spiritual sides.

Conclusions

In this light, extra-curricular activities must be acknowledged to be a part of the educational process rather than a parasite sapping its energy. Extra-curricular activities are supplementary to the formal educational process and can contribute positively to the professional development of engineering students by fulfilling many of the demands of industry without reducing the amount of curriculum time devoted to engineering subjects. Industry demands young men who are effective speakers and writers and possess the ability to work with others. Employers demand men who display initiative, leadership ability, decisiveness, sound judgment, and excellent character. If an attempt were made to develop these qualities by academic work, little time would be available for engineering subjects; extra-curricular activities are an economical means of meeting this requirement without impairing curricular strength.

In conclusion, it is worth noting that only a small percentage of engineering students participate in extra-curricular activities. These often are the students who, from the standpoint of professional development, perhaps have the least need to participate—either because they have done so before or have special abilities in the administrative areas. To a limited extent, therefore, students should be encouraged to participate in extra-curricular activities. This may necessitate the expansion of the number and types of extra-curricular activities at many engineering colleges.

ENGINEERING SOCIETIES DIRECTORY

On behalf of its constituent and associate groups, the Engineers Joint Council will publish this summer the *Engineering Societies Directory*, listing all local, regional, and national engineering societies. Included will be the name and purpose of each organization. Revisions will appear periodically. Publication price is $3.50, and orders should be sent to E. Paul Lange, EJC Secretary, 29 West 39th Street, New York 18, New York.

THE NEED FOR MORE "KNOW WHY"

JESS H. DAVIS

President, Stevens Institute of Technology
Hoboken, New Jersey

The vast and continuing increase in our understanding of physical phenomena in the past 15 years, as well as our ability to put this knowledge to work, has grown more than most of us realize. There are two ways of dealing with this great abundance of both new and classical knowledge in teaching young men to become good, useful engineers.

The first is the route the Russians have already taken. In Russia, the recognized engineering fields have been divided and subdivided, then the sub-divisions have been subdivided. A Russian engineering undergraduate is assigned to study in one of those many sub-sub-divisions. Each man is trained in a very limited field. When he graduates he is assigned to his lonely little slot, doing exactly what he was trained for and nothing else. From the kind of super-specialized training he gets, the Russian engineering student probably would find it difficult to move out of his slot—even if he dared to do so.

As a major step in increasing their industrial and war potential, the Soviets have greatly increased the number of their engineering colleges and the total engineering enrollment. There are estimated to be some 300,000 students in Soviet engineering schools as against our 150,000, and the margin is growing larger each year. The reason is obvious: if you are going to insist on specialists of very limited scope, you are going to need a great variety of them to cover the entire spectrum. To get high industrial production, you must have them in depth.

The Russians last year graduated 53,000 engineers to our 22,500. Obviously, we are not going to match the Soviets in numbers for a while yet, even if we should be able to treble our engineering school enrollment overnight. Our only hope of meeting this potential threat to our security and to our industrial leadership, it seems to me, is to put our emphasis on *quality*. By that I mean taking just the opposite tack from that of the Russians. Instead of trying to educate specialists who are good only in a limited field of engineering, let's throw away the blinders and let American engineering students see more of *all* the fields. Let us help them also to gain a better understanding of the relationship of each of the fields to the others.

Specialization is an integral part of industrialization. But if we hope to keep our free, industrial society supreme, our engineers and scientists must be men with greater breadth of view and the adaptability to make use of engineering knowledge in many fields, instead of a tiny corner of a single field. The bio-chemist and the bio-physicist, the physical metallurgist,

the physical chemist as well as the chemical physicist, show by their very titles how the fences are disappearing in science and engineering as we come to recognize more fully the universality of scientific truths. The engineering leader of the future must be at home in many branches of his calling if he hopes to help us reap the benefits that new scientific and engineering concepts make possible. The century ahead in science and in engineering belongs not to the specialist, but rather to the synthesist who can fit together many disparate truths and create a new truth.

The engineering undergraduate of the future will have to learn more of science, more of the engineering principles and, unfortunately perhaps, less of the practical applications. There will be fewer undergraduate classes in air-conditioning and more in thermodynamics, fewer in hydraulic turbines and more in fluid dynamics. There will be less design work of an empirical nature but a deeper study of mathematics and of the physical and engineering sciences where the principles of all designs originate. If we are to keep ahead of the world, there must be fewer engineering vocational schools and more engineering academies.

Engineers in industry are expert in converting new scientific discoveries to practical use and they are doing it at a rapid rate, as our advances in automation, electronics and nuclear devices illustrate. Researchers in our colleges, of course, also contribute, but industry itself is a much vaster and better-stocked laboratory for the development of the practical applications of science. By the same token, industry can and is doing a much better job than the colleges of teaching the "how-to-do-it" techniques which the new engineering graduate in industry must know. What the colleges can do best is to teach not the "hows" but the "whys" of the physical and engineering sciences. With this knowledge as a base, the new engineering graduate is a far more apt pupil in learning "how-to-do-it" techniques in the company or industry he joins.

As you know, a number of our larger industrial firms already have extensive programs for teaching engineering techniques peculiar to their own businesses. I believe these firms will continue to expand their programs and that other companies will start training programs of their own. Eventually industry will teach a major portion of the engineering applications of science, leaving it to the engineering colleges to concentrate on improving the undergraduate's understanding of the theoretical concepts on which the applications are based. I see no other way of enabling a student to cope with the new knowledge that keeps piling up in such awesome proportions.

What I am leading to is this: We have heard it said many times that it was the "know-how" of American industry that enabled us to overcome the enemy in the last shooting war. But, if American industry is going to keep ahead of the new enemy, its engineers must combine with their "know-how" a "know-why"—a broader, deeper knowledge of the laws of science and engineering and how those laws are put to use. Only by this "know-why" can we hit upon the new and startling inventions that will keep us ahead of the Soviets and their over-specialized technologists. More "know-why" will bring about the startling new "break-

throughs" that will open bright new opportunities like those brought on by the vacuum tube, the airplane, and the electron microscope.

I am glad to say that other engineering educators are thinking along these same lines. The Committee on Evaluation of Engineering Education of the American Society for Engineering Education recently made recommendations to the engineering colleges that they move to strengthen their undergraduate programs in the basic engineering sciences and make them a common core of all their engineering curricula. I feel sure that these recommendations will be incorporated in the curricula of all accredited engineering institutions within the next five years. That will mean that more of our colleges will have to weed out more and more of their "how-to-do-it" courses and I for one say, "good riddance."

NSF OFFERS GRANTS TO ATTEND BRUSSELS APPLIED MECHANICS CONFERENCE

The National Science Foundation is planning to assist a limited number of engineers and scientists in attending the ninth International Congress of Applied Mechanics in Brussels, Belgium, from September 5 to 13, 1956. Applications for these international travel grants should be submitted to the National Science Foundation, Washington 25, D. C., not later than August 1, 1956.

NSF AIDS 1957 SUMMER INSTITUTES

To encourage a greater number of Summer Institutes for high school and college science teachers in 1957, the National Science Foundation will offer Institute participants financial support of approximately seventy-five dollars per week plus fifteen dollars per week for each dependent. Colleges and other institutions which are planning Summer Institutes should submit their proposals to the NSF by September 1, 1956. Those proposing approved programs will receive funds that are to be used to sponsor Institute participants. Details can be obtained from Harry C. Kelly, Assistant Director for Scientific Personnel & Education, National Science Foundation, Washington 25, D. C.

THE FUTURE OF LIBERAL SCIENTIFIC EDUCATION

Excerpts from an Address
January 4, 1956, New York City

DR. JAMES R. KILLIAN, JR.

President, Massachusetts Institute of Technology
Cambridge, Massachusetts

"... An institute of technology stands today in the main current of contemporary life, generating the discoveries and ideas, and educating the kind of men which shape our industrial society. The scientist, the engineer, and the manager are among the chief architects of our flourishing technological society, and their responsibility grows steadily greater for its state of health and for its advancement. The professional competence and insight expected of the scientist and engineer, and their understanding of the social forces they affect and are influenced by, all become greater as our society becomes more complex and as our nation assumes greater responsibility and faces greater hazards. . . ."

"With technology playing an important role in our national life, our institutions where science, engineering, and management are taught have a correspondingly important role to play and must as a consequence be closely meshed with both the immediate and long-term needs of our society. In a period of manpower scarcity they must accept additional educational responsibilities in order to augment our scientific manpower resources—responsibilities which require enhancing quality while increasing numbers. In a period of cold war they have a uniquely specialized part in the technology of survival—the survival of ourselves and of the free world.

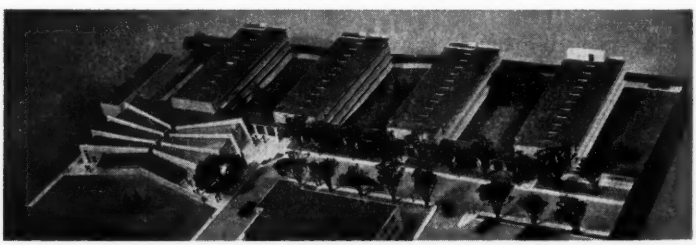
"They have a responsibility to further our basic science and to achieve those subtle environmental conditions where the creative mind flourishes best. In a period when society vests a growing responsibility in scientist and engineer, these educational institutions have the responsibility of educating professional men so that they can both advance their specialties and at the same time play an important role as perceptive, broadgauged citizens contributing to the common account. To do this, these institutions must achieve new working coalitions of the sciences, the social sciences, and the humanities.

"Our institutions of technology may well be leading the way to a liberalized liberal education that is relevant to the needs of modern man and of modern technological society. A superb opportunity exists to provide a new type of liberal education polarized about science and given new coherence and standards by professional requirements. In our institutions of technology there is a vision of a new kind of indigenous American university built around science and social technology but embracing the arts, the social sciences, and the humanities as essential and equal partners in its

corporate aims and culture. The liberal arts cannot fulfill their responsibilities if scientists and engineers lack the humanistic quality once ascribed to the Athenians—the art of making gentle the life of mankind. Our great schools of science and engineering have a special responsibility today to develop new bridges interconnecting the sciences, the social sciences, and the humanities, to reduce the protective tariffs of intellectual vested interests, and thus to achieve a liberal education that is liberal in the deepest sense for our American civilization."

COLORADO A & M PLANS NEW ENGINEERING CENTER

One of the first groups of buildings to be planned by Colorado Agricultural and Mechanical College under its new program authorized by the last session of the Legislature will be an integrated unit for the School of Engineering. As shown below, the new Center will consist of three three-story structures connected by an arcade. A fourth building, matching those for engineering, will be devoted to work in physics, and an adjoining lecture hall will seat 300. Each of the wings will have laboratories of one department on the first floor, but other facilities for classes and drafting will be used in common. Construction is to be completed by the fall of 1957, when all departments will move to the new center; a capacity enrollment of 800 students is expected for the following session.



IN THE NEWS

Rensselaer Receives Grant for Architecture Lectures

Rensselaer Polytechnic Institute recently received from the Aluminum Company of America Foundation a grant of $2,500 to inaugurate a series of lectures by eminent architects and outstanding authorities in allied fields. Students will thus be given a better acquaintance with the leaders in the field of architecture, and the R.P.I. architectural program will benefit from the fresh points of view presented.

Cornell Offers Industrial Engineering Seminars

The Sibley School of Mechanical Engineering, Cornell University, will offer its Annual Industrial Engineering Seminars from June 12 through June 15. The series will be concerned with Industrial Management, Manufacturing Engineering, Small Plant Management, Methods Engineering, Applied Industrial Statistics, and Industrial Marketing. Discussion leaders and speakers will include specialists from both industry and the Cornell staff. Additional information can be obtained from Andrew Schultz, Jr., Department of Industrial and Engineering Administration, Cornell University, Ithaca, New York.

Law and Industrial Engineering at University of Tennessee

A new curriculum combining law and industrial engineering has been announced by the University of Tennessee, Knoxville. Without losing credits towards his engineering degree, a senior industrial engineering student may take law courses to test his ability and interest in the field. If he likes the arrangement, he continues his joint work the fifth year, receiving his engineering degree. Then he adds a sixth year-and-a-quarter to obtain his law degree. The program is designed to save time for students who wish to fill management positions requiring legal training.

. . . . . YET-ITUDES

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

JOHN L. ARTLEY, Chairman
Duke University

HAROLD A. FOECKE, Editor
University of Notre Dame

THE UNCONSCIOUS ART

LEE HARRISBERGER

Assistant Professor of Mechanical Engineering
North Carolina State College, Raleigh

This is about the time of year that, for the new teacher, means the end of a pretty hectic session. As a matter of fact, he's glad it's about over, for he probably has a feeling that he was the only one in class that learned anything. The only consolation he has is a chance to do better next fall.

Most of us who have been teaching more than a couple of years are likely to forget what a difficult time it was for us. We never stop to realize how much we've learned about the art of teaching. We rarely give much thought to how we teach our classes; it's just a matter of deciding what material we're going to cover, planning lectures and assignments, writing tests and letting it go at that.

Actually, skill as a teacher is attained almost unconsciously. It would be hard to tell a new instructor exactly how to teach his first class. Oh, we could tell him how to plan his schedule and cover the material—but could we define or outline the subtle moves involved in the human relations of teacher and student?

A new teacher is faced with two devastating conditions when he enters his first engineering class: First, he possesses a demoralizing lack of confidence in his knowledge of the course and what to do about it. Second, students can smell a neophyte a mile away and will inevitably set out to give him a "hard time." After all, most of the students' classroom experience was gained under the "old hands." Now they're cocky enough to think they can match a new man in a duel of wits. Students take delight in attempting to skewer a young instructor to his blackboard and then leave him dangling helplessly on an intellectual impasse.

For the first year, at least, the instructor faces constant challenges—questions he has never thought of before, problems he has never worked, students who buck his system and attack his statements, his grading, solutions, methods, fairness, and answers.

After you've been teaching a while you never seem to have such troubles. There are few problems; the students

take an interest in the course and seem to respond well. There are no embarrassing impasses. If a young teacher should ask how you would handle a situation like this or that, you're somewhat surprised; you never have anything like that happen any more. I suspect we'd have to lean back, stare at the ceiling for a minute and say, "Just what would I do if that happened in my class?"

What, then, makes up this unconscious art of teaching? Generally, we develop a capacity to sense the student or class reaction and take advantage of it or head it off. We learn what will arouse interest and what won't. But above all, we have learned we're teaching *students* instead of thermo or mechanics.

As experience grows, we put more effort into teaching the student than into covering the material. Our lectures take on more color, include more sidelights, less technique and detail. We try to motivate the student, to challenge his curiosity and enthusiasm. We finally learn how to put the burden back on the student, where it belongs. We decide what is important in the course, show the student the way, then follow him and keep encouraging him forward. Instead of racing across the board in a cloud of derivations and arriving triumphant at the solution only to find we're the only one there, we begin to learn it's not what WE know that counts, but what *they* know.

These are the things we've learned to do—but we can't exactly put into words how we do them. We're apt to say, "Well, it depends on how things are going."

If you are a new teacher just finishing up your first semester or year, take heart. You would be surprised to know how much you've learned about the unconscious art of teaching. Just watch how much better next fall will be. Keep these things in mind and you'll find you'll soon become a teaching addict.

You can't *show* them a thing—they remember very little of what they see done, and can rarely duplicate it.

They learn what they do for themselves, by themselves.

Your only purpose is to make the subject so interesting and challenging they will "eat it up."

Be fair and humble; never be afraid to admit you're wrong or don't know. But try to find out before next class.

Notice that these injunctions have nothing to do with what you teach. What counts is how you go about it. No one can tell you exactly how to teach; it's the unconscious art developed by being conscious that you're *teaching—not* lecturing.

DIRECTORY REVISION PLANNED

Preliminary correction of the ASEE membership lists for the 1957 Yearbook issue is now in process, and type changes will be made as of July 15, or as soon thereafter as possible. Please check your listings and inform the Editorial Office if revision is indicated. For those who are moving this fall, a final postcard inquiry will be sent later to all members, returnable by October 15.

GRAPHIC SCIENCE

Analysis—Synthesis—Communication

Sponsored by the Division of Engineering Drawing
Editor: Albert Jorgensen, University of Pennsylvania

A GRAPHICS COURSE FOR SCIENCE MAJORS

EUGENE PARÉ

Illinois Institute of Technology, Chicago

A paper presented at the Midwinter Meeting of the Drawing Division, Chicago, January 27, 1956.

A few years ago our department was asked to develop a basic drawing course for students majoring in chemistry, mathematics, and physics. Consultation with the interested departments revealed that something different from our standard offering for engineering students was desired. A broader course that contained less specialization in the instrumental drafting of machine parts, and which would promote better freehand graphical presentations in scientific reports, was requested. At the same time it was essential that we retain most of our training in orthographic visualization, because the science students were expected to have a solid foundation for blueprint-reading.

Fresh View

Generally, a fresh point of view was required rather than a change in topics. For instance, problems in geometric construction and basic orthographic projection were just as well selected from chemistry and physics as from mechanical engineering. Freehand execution in many cases replaced the instrumental technique.

Some new topics were added, however, including:

1. Use of mechanical lettering devices.
2. Title design for laboratory reports.
3. Preparation of bar graphs, line graphs, rate-of-change graphs, percentage charts, and organization charts.
4. Graphical mathematics, including curve plotting, roots of equations, solutions of simultaneous equations, periodic functions, development of empirical equations, vectors, and introduction to nomography.

These innovations represented a thirty per cent addition to our program, so it was necessary to make substantial cuts in the traditional material. The time previously devoted to dimensioning, screw threads and fasteners, and production of working drawings was, therefore, drastically reduced. The student was introduced to these curtailed topics through the medium of problems which required blueprint-reading.

Order of Topics

The order of topics for the entire course is as follows:

Evolution of graphical representation. In our introductory lecture, we trace the historical development of drawing as a means of communication. We discuss the accumulated wealth of man's experience and knowledge leading to the development of Monge's system of orthographic projection. Reference is made to drafting standards and the necessity for continual revision to keep in step with industrial advances.

Mechanics of freehand and instrumental drawing. Particular emphasis is placed on freehand execution. The student is given instructional assistance while acquiring this technique. Similarities between freehand lettering and freehand drafting are considered.

Freehand lettering and mechanical lettering devices. Each student is required to purchase the relatively inexpensive Doric lettering tool, and about sixty per cent of the lettering in the course is performed with this mechanical lettering aid.

Title design for reports. The student is not presented with a set of rigid rules for titles, but rather is encouraged to experiment with original patterns of his own, particularly in the area of non-symmetrical design.

Use of measuring equipment. As we are concerned with science students, a good deal of attention is directed to the metric and American decimal systems.

Graphic constructions. Under this topic, problems have been obtained that involve such pertinent equipment as the Centigrade and Fahrenheit thermometers, laboratory standards, electric cell, ammeter, centrifuge, Erlenmeyer flask, thistle tube, and pulley systems. In this connection, we find that we are dealing not only with graphic representation, but with physics as well.

Charts and graphs. The student is introduced to the use of colored pencils for both lines and shading. Problems are presented in which the student deals with the electro-chemical equivalents of selected elements.

Orthographic drawing. This topic includes selection of views, orthographic reading, and sectioning.

Primary Auxiliaries. Under these topics, dealing directly with orthographic projection, we are more concerned with the student's ability to visualize than with his drafting proficiency.

Pictorials. Isometric and oblique are both formally presented, although the students have been introduced to pictorial sketching earlier in the course. Some basic concepts of line and smudge rendering are also discussed.

Graphical mathematics. We deal with the accurate plotting and significance of equations, graphical intercepts, simultaneous equations, use of rectangular coordinate and logarithmic paper for the production of empirical equations, the graphical addition and subtraction of periodic functions, alignment diagrams, dimensioning analysis, and blueprint-reading.

Elements of design. I believe we have devised a final project that could well be employed in any basic drawing course. The student is provided with a blueprint of a vise base, complete with detail specifications for screw threads and limit dimensions.

To find answers for many of the questions presented in this problem,

the student finds it necessary to utilize a textbook for reference. He must, for the first time, discover the meaning of a thread note; he must indicate the tolerances for both fractional and limit dimensions. In all, some fifteen questions based on the drawing provide a measure of the student's ability to visualize, and at the same time the print introduces several new features of industrial drawings.

After this blueprint-reading portion of the assignment has been completed, the student is confronted with an original design project of his own. Using the given vise base as a control, he is asked to create the design for a suitable sliding jaw to work with the base. The drawing is done freehand, but is presented complete with dimensions and other specifications. The student is left pretty much to his own devices, and as you can well realize, he again finds his textbook a valuable reference.

Interesting to Teach

The course has been an interesting one to teach. Apparently it has been equally stimulating to the student; after completing the course, three of our current science majors transferred to our teacher-training program in drawing.

In teaching methods, several alterations were made that helped to conserve time and improve presentation. The descriptive geometry approach was introduced early in the course and treated as a method of visualization throughout the semester. Problem-solving was utilized more as an instructional aid than as a device for measuring drafting skills. About forty per cent of the laboratory time was devoted to practice problems. Some were solved by the entire class as part of a blackboard presentation. Others were separate problems distributed according to student abilities with the solutions discussed on completion. By this recognition of individual differences, the skill in visualization of the slower student developed, and at the same time the more adept student was presented with more challenging material.

Re-Orients Concepts

The development of this course has been a valuable addition to our departmental offerings. It has, I am sure, been of even greater significance to me as a teacher, for it has served to re-orient some of my basic concepts on the teaching of drawing. It has stimulated my interest in experimenting with different teaching methods and has caused me to question traditional course content.

In general, I believe that we as drawing teachers are hesitant about experimentation, for we have always been rather proud of uniformity. We have developed or purchased expensive films and other visual aids which we hesitate to set aside even for a semester. We have accumulated a collection of good problem material which we religiously employ year after year. We are reluctant to change that which has served us well, but our devotion to the traditional tends to impede rather than encourage our progress.

Perhaps we ourselves should take the initiative in the development of simplified drafting methods, rather than just offer resistance to such experiments by industrial leaders. Perhaps we should concentrate less effort on formal problem-solving and devote

more time to other instructional methods. Perhaps we should not strive for such a high degree of drafting proficiency, but rather utilize the time to introduce broader concepts of graphical representation. We might teach the economics of dimensioning rather than the technique of size-description. We could introduce some aspects of the geometry of design rather than the formal execution of working drawings.

Experiment!

Might it not be wiser if we reduced handbook drafting (such as the representation of screw threads, springs and fasteners) and apply the time saved to a more thorough treatment of the theory of projection? Yes, there are many things we can do. But whatever we do, let us not be content with the status quo; let us set aside the traditional—let us experiment!

WEBER ACTING PRESIDENT

Dr. Paul Weber, a member of the ASEE since 1944 and Dean of Faculties at the Georgia Institute of Technology, has been named Acting President of the Institute until a successor to the late Dr. Blake R. Van Leer is appointed. At Georgia Tech since 1927, Dr. Weber had served as professor of chemcial engineering and Director of the School of Chemical Engineering until he was appointed Dean on July 1, 1955.

ROYS APPOINTED VICE PRESIDENT

Dr. Francis W. Roys, a member of the ASEE since 1925, has been appointed Vice President of Worcester Polytechnic Institute, effective April 1, 1956. Dr. Roys, who is Chairman of the WPI faculty as well as Dean of Engineering, has been associated with the college since his graduation there in 1909. From 1923 to 1949, he served as head of the mechanical engineering department. He became Dean of Engineering in 1939 and Dean of Students in 1954. He will continue as Dean of Engineering.

CRONVICH TULANE DEAN

Member of the ASEE since 1950, James A. Cronvich, professor of electrical engineering at Tulane University, has been appointed Dean of the department of electrical engineering in the Tulane School of Engineering. He will succeed C. W. Ricker, a member of the Society since 1921, who will retire June 30 after serving for 28 years as member of the Tulane engineering faculty.

TEACHING POSITIONS AVAILABLE

MECHANICAL ENGINEER NEEDED AS Associate Professor or Professor and Department Head. Fields of Machine Design, Air Conditioning, Heating, and Ventilation preferred. Department has recently moved into new building and is equipping new laboratories. Housing available at reduced rates. Location, South. MAY-3.

ELECTRICAL, MECHANICAL, CHEMical Engineering, and also Mathematics and Physics staff openings. Industrial experience desirable. Opportunity for research. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Massachusetts.

CHRYSLER INSTITUTE OF ENGINEERing again has openings on its full-time teaching staff. For: supervisor of engineering graduates working on individual automotive design projects as a part of their Graduate School course. Duties would also include supervision of graduate classwork. Desired qualifications are age 25–40; B.S. degree or higher in engineering; at least 2 years of college teaching experience; some design experience, preferably automotive. Also a teacher and supervisor of Graduate School classwork. Qualifications are age 25–40; M.S. degree in engineering; experience in teaching Mechanical Engineering subjects. Write to Chrysler Institute of Engineering, Att: L. R. Baker, Director, P. O. Box 1118, Detroit 31, Michigan.

ASSISTANT PROFESSOR OR INSTRUCtor to teach fundamental heat power and related fields. Compensation dependent on qualifications. Long established college, high professional reputation. Graduate Study opportunities available. Location, New York City. Appointment to start September, 1956. Send resumé. MAY-1.

ASSOCIATE PROFESSOR, ASSISTANT Professor, or Instructor, (rank and salary determined by training and experience) to teach courses in the Petroleum Production Option. Teaching period nine months. Opening, September 1, 1956. Location, Southwest. MAY-2.

MECHANICAL ENGINEERING POSItion to teach undergraduate courses in thermo-fluids and heat transfer. M.S. preferred. Opportunities for graduate study, industrial consulting, and research. Rank and salary open. Start September, 1956. University of Santa Clara, California.

ASSISTANT PROFESSOR AND INstructor in mechanical engineering, beginning September 1, 1956. M.S. degree or equivalent. One applicant should be qualified to teach basic thermodynamics and heat power courses, the other kinematics, and machine design, together with heat power laboratory. Salaries commensurate with qualifications. Apply to Professor W. M. Richtmann, Head, Department of Mechanical Engineering. Colorado School of Mines, Golden, Colorado.

ELECTRICAL ENGINEERING PH.D. needed for teaching and research. Also Instructor for same duties; B.S. degree acceptable if willing to work toward M.S. Salaries commensurate with qualifications. Write Head, Department of Electrical Engineering, University of Denver, Denver 10, Colorado.

ELECTRICAL AND MECHANICAL ENgineering Associate and Assistant Professors and Instructors needed. Permanent opportunities in expanding programs. M.S. degree desirable. Fellowships available for part-time graduate work in state university at M.S. level. Please forward complete details of education, practical experience, and personal background to Dean of Engineering, Milwaukee School of Engineering, Milwaukee, Wisconsin.

ASSOCIATE, ASSISTANT, PROFESSOR or Instructor, rank dependent upon training and experience, to teach basic mechanical engineering courses. Machine design experience preferred. M.S. degree or teaching experience desirable. Position available September 1, 1956. Write to Head, Department of Mechanical Engineering, South Dakota State College, State College Station, Brookings, S. D.

MECHANICAL OR INDUSTRIAL ENGINEER with B. S. degree as Assistant Professor to teach manufacturing processes and to be in responsible charge of all machine laboratories. Position starts September, 1956. Salary on nine months basis. Write to Chairman of Mechanical Engineering Department, University of Delaware, Newark, Delaware,

ASSISTANT PROFESSOR OR INSTRUCTOR needed in electrical engineering, beginning September, 1956. Must be qualified and interested in teaching basic undergraduate courses plus one graduate course. Ph.D. or M.S. required, with salary dependent on qualifications. City location with many industrial contacts. Apply to Department of Electrical Engineering, Saint Louis University, St. Louis 8, Mo.

ENGINEERING DRAWING AND DESCRIPTIVE geometry position open. Engineering degree necessary. Opportunity to do graduate work. Rank and salary dependent upon applicant's education and experience. Send inquiries to E. J. Marmo, Professor and Chairman of the Department of Engineering Mechanics, University of Nebraska, Lincoln, Nebraska.

ELECTRICAL ENGINEERING TEACHING-research positions available at Assistant and Associate Professor level for graduate and undergraduate courses in communications, circuits, and computers. Ph.D. desirable, M.S. essential. Appointments to begin September, 1956. Apply to Professor Joseph C. Michalowicz, Catholic University of America, Washington 17, D. C.

CONTINUATION OF EXECUTIVE BOARD MINUTES

From page 813; for beginning of report, please see page 807.

19. *AAAS Suggestion for Contributions*

The Executive Board agreed the Society could not pay AAAS $25 per representative for travel expenses of AAAS Council representatives to attend meetings, because the Society is not able to provide funds for its own Council members to attend ASEE meetings.

20. *Survey of the Teaching of English In Engineering Schools*

Thomas Farrell, Jr., Chairman of the English Division, was granted permission to appear before the Executive Board on Friday night to discuss the proposed study. The Secretary read the action of the General Council taken in November, explaining that almost all of the financing of projects pending at that time has been completed, and that neither the Report On Evaluation of Engineering Education or the Report On the Humanistic-Social Research Project included the study of English, whether oral or written. Professor Farrell stated financial sponsors were available and discussed the financing. The Executive Board VOTED to recommend approval of the project, as a policy matter, to the General Council at its next meeting.

Professor Farrell also stated the English Division would like to take a more active part in the affairs of the Society, and raised the question of bringing technical writers and editors into ASEE.

Respectfully submitted,
W. LEIGHTON COLLINS, *Secretary*

NEW MEMBERS OF THE ASEE

AHLMAN, TORSTEN, Instructor in Engineering Graphics, Purdue University, Lafayette, Indiana. Warren J. Luzadder, J. B. Jones.

ALVERSON, ROY CARL, Research Assistant in Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, Samuel Lerner.

ANDERSON, CARL ANDREW, Graduate Assistant in Aeronautical Engineering, Institute of Technology, USAF Wright-Patterson AFB, Ohio. Paul C. Dow, Jr., Gunther R. Graetzer.

ANDERSON, GORDON FRANCIS, Research Associate in Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, Samuel Lerner.

ANDERSON, JOHN ROBERT, Assistant Professor of Engineering Drawing, University of Miami, Coral Gables, Florida. W. Hubbell, J. H. Clouse.

ANGULO, CARLOS MANUEL, Associate Professor of Engineering, Brown University, Providence, Rhode Island. D. C. Drucker, Z. Bliss.

BEDELL, ROBERT K., Instructor in Mechanical Engineering, The Cooper Union School of Engineering, New York, New York. M. Alpern, William Vopat.

CAMPBELL, ROBERT JOHN JR., Assistant Professor in Ceramic Engineering, University of Washington, Seattle, Washington. J. I. Mueller, D. C. McNeese.

CLIFFORD, WAYNE E., Engineering Personnel Manager, Airesearch Manufacturing Co., Los Angeles, California. D. E. Whelan, Jr., Robert Moses.

CREVELING, JOHN H., JR., Coordinator of Cooperative Program Engineer, University of California, Berkeley, California. E. P. De Garmo, L. E. Davis.

D'ERRICO, THOMAS R., Associate Professor in Civil Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. R. A. McFarland, B. T. Bogard.

DUFFY, JACQUES W., Assistant Professor in Engineering, Brown University, Providence, Rhode Island. Samuel Lerner, Z. Bliss.

EMBRY, BERTIS LLOYD, Associate Professor in Electrical Engineering, Utah State Agricultural College, Logan, Utah. Larry S. Cole, J. E. Christiansen.

FERRAND, EDWARD FRANCIS, Assistant Professor in Chemical Engineering, Cooper Union, New York, New York. Arthur H. Radasch, J. Merriam Peterson.

GORMAN, PAUL J., Engineering Drawing Instructor, Franklin Technical Institute, Boston, Massachusetts. R. R. Borden, L. R. Dantona.

HAMILTON, JAMES FRANCIS, Assistant Professor in Mechanical Engineering, West Virginia University, Morgantown, West Viriginia. R. D. Slonneger, J. M. Strait.

HAYT, WILLIAM HART, JR., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Indiana. Stuart Johnson, Philip Weinberg.

HAYTHORNTHWAITE, ROBERT MORPHET, Assistant Professor in Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, D. C. Drucker.

HERNLEY, KENNETH PAUL, Instructor in General Engineering, University of Washington, Seattle, Washington. D. C. McNeese, Thomas W. Macartney.

INGRAM, GERALD E., Instructor in Civil Engineering, Purdue University, Lafayette, Indiana. J. H. Porsch, J. N. Arnold.

KENT, JOSEPH C., Assistant Professor in Civil Engineering, University of Washington, Seattle, Washington. J. A. Higbee, B. T. McMinn.

LARSEN, LAURIE WORDEN, Training Coordinator, Personnel, Airesearch Mfg. Co., Los Angeles, California. D. E. Whelan, Jr., Robert Moses.

LIEBESKIND, HERBERT, Assistant Professor in Chemical Engineering, The Cooper Union, New York, New York. Milton Alpern, Richard G. Coulter.

LOCKHART, FRANK JONES, Professor of Chemical Engineering, University of Southern California, Los Angeles, California. C. M. Beeson, R. E. Vivian.

MAEDER, PAUL FRITZ, Professor of Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, Samuel Lerner.

MAYER, HERBERT CARLETON, JR., Supervisor of Education, General Electric Co., Kennewick, Washington. Melbourne Jackson, J. Hugo Johnson.

MOORE, RICHARD K., Associate Professor, Acting Chairman, Electrical Engineering, University of New Mexico, Albuquerque, New Mexico. M. E. Farris, R. C. Dove.

MURPHY, CLINTON ELLIS, Instructor in Engineering, Texas College of Arts and Industries, Kingsville, Texas. C. V. Mooney, F. H. Dotterweich.

MURPHY, KARL M., Assistant Professor, English Department, Georgia Institute of Technology, Atlanta, Georgia. R. L. Sweigert, Alton A. Hobgood.

NAMYET, SAUL, Assistant Professor in Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts. John B. Wilbur, Myle J. Holley, Jr.

NASH, CHARLES DUDLEY, JR., Instructor in Mechanical Engineering, The Ohio State University, Columbus, Ohio. George N. Moffat, W. L. Starkey.

PAINTER, JACK TIMBERLAKE, Assistant Professor in Civil Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. R. A. McFarland, R. A. Smith.

PECK, GEORGE VAIL, Professor in Civil Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania. W. Irwin Short, R. F. Edgar.

PFEFFER, CHARLES B., Assistant Professor in Engineering Drawing, University of Wichita, Wichita, Kansas. W. A. Simons, Everett L. Cook.

RAUTALA, PEKKA, Associate Professor in Chemical and Metallurgical Engineering, Purdue University, Lafayette, Indiana. T. J. Hughel, R. Schuhmann, Jr.

RESNICK, ROBERT, Assistant Professor in Physics, University of Pittsburgh, Pittsburgh, Pennsylvania. W. Irwin Short, John W. Graham, Jr.

ROPER, KENNETH HALL, Instructor, Aeronautical Engineering, Institute of Technology, USAF, Wright-Patterson AFB, Ohio. V. S. Haneman, Jr., P. C. Dow, Jr.

ROY, FRANCIS C., Assistant Professor in Mechanical Engineering, Louisiana Polytechnic Institute, Rushton, Louisiana. J. C. Ramsaur, J. G. Chumley.

SANTALO, MIGUEL ANGEL, Assistant Professor in Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts. W. A. Wilson, A. L. Townsend.

SHAPIRO, ELI, Associate Dean and Professor of Finance, School of Industrial Management, Massachusetts Institute of Technology, Cambridge, Massachusetts. E. H. Schell, E. L. Bowles.

SOGIN, HAROLD H., Assistant Professor of Engineering, Brown University, Providence, Rhode Island. D. C. Drucker, Z. R. Bliss.

SUN, HUN H., Assistant Professor in Electrical Engineering, Drexel Institute of Technology, Philadelphia, Pennsylvania. Martin N. Kaplan, I. Cogan.

SYMONDS, PAUL SOUTHWORTH, Professor of Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, D. C. Drucker.

ULRICH, EDGAR, Mechanical Engineer, Pennsylvania State University, Ordnance Research Laboratory, State College, Pennsylvania. A. T. Thompson, R. F. Marboe.

VANZANT, HOWARD CLAY, Instructor in Engineering, Texas Western College, El Paso, Texas. Floyd A. Decker, Eugene M. Thomas.

WALTERS, ROBERT E., Instructor in Mathematics, University of Louisville, Louisville, Kentucky. Leo B. Jenkins, Jr., J. R. Snowden.

WANG, HUNG-EN, Research Assistant in Engineering, Brown University, Providence, Rhode Island. Paul Kistler, Z. R. Bliss.

WIESNER, JEROME BERT, Professor of Communications and Director, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts. M. M. Boring, W. L. Collins.

WILBURN, RAYMOND N., Supervisor, Engineering Education, The Glenn L. Martin Company, Baltimore, Maryland. John M. Hollyday, H. R. Bartlett.

WOOD, ALBERT DOUGLAS, Research Assistant in Engineering, Brown University, Providence, Rhode Island. P. Kistler, Z. R. Bliss.

50 new members
481 previously added

531 new members this year

FRANK C. HOCKEMA

A member of the ASEE from 1921, Dr. Frank C. Hockema died February 3, 1956, in Lafayette, Indiana. For more than ten years, he had served in the dual capacity, both as Executive Dean and as Vice President of Purdue University. In addition to these administrative duties, he served as professor of mechanical engineering, secretary of the Purdue University Board of Trustees, and as an industrial consulting engineer. He was also regional director for the Association of Governing Boards of State Universities and Allied Institutions.

JAMES B. MACELWANE

James B. Macelwane, S. J., Dean of the Institute of Technology, Saint Louis University, died February 15, 1956, in St. Louis, Missouri. A member of the ASEE since 1946, Father Macelwane was Chairman of the Missouri-Arkansas Section for 1955–1956. An eminent geophysicist, he developed seismographic processes for locating petroleum and mineral deposits. He was also serving as the Chairman of United States activities in connection with the Geophysical Year.

MINUTES OF THE EXECUTIVE BOARD MEETING

Park Lane Hotel, Denver, Colorado
April 27 and 28, 1956

Editorial note: For JOURNAL presentation the minutes below have been shortened somewhat by omitting details of an informational nature. Questions pertaining to the minutes should be directed to the Secretary.

A meeting of the Executive Board of The American Society for Engineering Education was held in Room 608 of the Park Lane Hotel at Denver, Colorado, on April 27, 1956, 6:30 P.M. Because of the forty-odd items on the agenda, the meeting was adjourned at 11:30 P.M. to 28 April, when another dinner meeting was held, the time and place being the same. The Board also on 28 April attended the sessions of the Rocky Mountain Section of the Society at the University of Denver. Those present at both sessions were: M. M. Boring, President; F. C. Lindvall, L. J. Lassalle, W. T. Alexander, and H. K. Work, Vice Presidents; G. W. Farnham, Treasurer; W. Leighton Collins, Secretary; and E. C. McClintock, Jr., as Editor. Thomas Farrell, Jr., Chairman of the English Division, was present for a short time on April 27.

1. *Report of the Secretary,* W. Leighton Collins

(a) After having been sent the usual three dues notices, there still are 856 individual members and 9 institutional members who have not paid their dues. The total value of the arrearages is almost $11,500. A special letter was sent to the institutional members by the Secretary and to the individual members by the Treasurer. The Executive Board VOTED that the Secretary adhere to the provisions of the Constitution and submit to the General Council at each Annual Meeting a list of members whose dues will be two years in arrears at the end of the current fiscal year, the General Council at its June meeting then taking action to drop from membership at the end of the current fiscal year all who are still two years in arrears at that time. It was suggested that the drop notice be sent by certified mail.

The Executive Board also VOTED to refer to the Constitution and By Laws Committee a possible change in Section 5 of Article XI, second sentence, believing that "dropped from the role of the Society until such arrearages are paid" is unworkable for efficient office practice. A "dead file" of members is not maintained, and members once dropped resent or refuse to pay two or three years back dues when they want to rejoin. It was believed paying arrearages for the one year such members receive the JOURNAL would be more appropriate; for this purpose, perhaps, a file of dropped and resigned members should be maintained.

(b) About 500 new individual members have joined the Society during

the fiscal year. Associate Institutional Members approved since the last meeting of the Executive Board are: American Viscose Corporation; Vickers, Inc.; International Paper Company—Southern Kraft Division; Sperry Gyroscope, Division of Sperry Rand Corporation. The following were submitted for Associate Institutional membership and the Executive Board VOTED to approve them: McDonnell Aircraft Corporation; Charles Bruning Company; Convair—A Division of General Dynamics Corporation. The Executive Board also VOTED to accept Sacramento State College as an Affiliate Institutional member.

(c) The plans for disposing of excess volumes of *Proceedings* to libraries both overseas and in this country has reduced the number stored at Lancaster Press (volumes 1 through 55) from about 1200 to 225. Extra copies of the JOURNAL currently being held for *Proceedings* use have been reduced by 100; this economy is expected to avoid an excess of current volumes.

It was agreed to refer to EJC the U. S. Information Agency's letter of December 22, 1955, complimenting the Society for its cooperation and lamenting the lack of current technical periodicals available for distribution abroad.

(d) 10,000 copies of the Humanistic-Social Report are being printed and, in addition, it will be presented in the April issue of the JOURNAL. The letter ballot of the General Council was overwhelmingly in favor of acceptance of the report. Though the report is longer than originally planned, it was agreed the selling price should remain at 25¢ each, 20¢ each for lots of 50 to 100, and 12¢ each in lots of 100 or more. John Mattill of MIT, Chairman of the Public Relations Committee, prepared a news release for the report. The material was assembled in cooperation with the Carnegie Corporation, the grantor of the funds for the project, and the director of the project.

(e) The papers presented for the Nuclear Institute at Northwestern University in 1954 have been turned over to the Secretary. Since the original budget included an item for publication of a report, the Executive Board authorized the Secretary to investigate the availability of the funds and, if adequate, to develop plans for publishing the papers, charging all costs thereof to the fund.

(f) Reports were made on the following summer programs.

1. *Institute on Mathematics In Engineering.* Dean F. C. Lindvall reported that the remainder of the funds had been transferred to the University of Michigan, and that Professor George Hay was now completing the details of the program.

2. *Institute for Engineering Teachers at Argonne National Laboratory.* The Secretary reported that the letter ballot of the General Council unanimously approved the Argonne Institute. About 160 applications to attend had been received; only 60 could be accepted. As a result of this interest, the holding of a similar course at Brookhaven National Laboratory for 30 applicants is being investigated. The Executive Board VOTED to approve the institute at Brookhaven because it actually is merely an extension of the Argonne program.

3. *Summer Schools.* The Secretary reported that the programs for the three summer schools to be held in conjunction with the Annual Meeting

at Ames (Humanistic-Social, Construction Education, and Engineering Drawing) are essentially complete, and that a brochure publicizing them had been prepared and mailed.

4. *YET Program.* President Boring reported that the proposed program did not develop because only one company made a firm commitment. The proposal had been to employ YETS for the summer and give them a month's leave of absence, with pay and expenses, to attend a conference on teaching techniques and methods.

5. *General Electric Summer School.* President Boring reported that because ASEE's YET program for the summer failed to materialize, the General Electric Company desired to repeat its summer school for college teachers. The General Electric Company will select 30 YETS and bring them together to learn something of how industry operates. G. E. pays all expenses and it has been customary to seek ASEE approval. The Executive Board VOTED to approve the program.

(g) Because some institutional members are receiving two copies of the JOURNAL OF ENGINEERING EDUCATION and others one, the Executive Board VOTED that all Institutional members should receive two copies of the JOURNAL if they desired them.

(h) At the suggestion of Lancaster Press, steps were successfully taken to obtain a lower mailing rate for the JOURNAL. A saving of about $270 per year should result.

(i) In response to a request received, the Executive Board VOTED not to establish a group subscription rate for the JOURNAL.

(j) Board members attended ten Section meetings and two Mid-Winter Division meetings during the year. It was agreed that next year an attempt should be made to have a national officer visit the Sections not visited this year, the Secretary's office serving as a clearing house for requests in order to avoid duplication of travel. Expenses for attendance of officers to some of these meetings can be paid by the Society.

(k) M. M. Boring was invited, as President of the Society, to represent ASEE on the National Committee for Development of Scientists and Engineers. The Executive Board authorized the Secretary to write President Eisenhower stating that the Executive Board believes Mr. Boring can best represent the Society on this committee, such representation not being contingent upon his being President of the Society.

The Executive Board VOTED that officers appointed to *ad hoc* committees should continue on the committees until the work is completed, regardless of whether or not they are still in office.

(l) The Executive Board VOTED to recommend to the Constitution and By Laws Committee that all officers of the Society be kept on the General Council for three years after stated terms of office expire, and that a copy of this recommendation be sent to the Society Functions Committee.

2. *Report of ECRC,* H. K. Work

(a) The Executive Board VOTED to approve the name "Vincent Bendix Medal" for the gold medal to be given annually for outstanding research, and to require a "termination clause," such as one year's notice by either party, in the agreement to be made with the Bendix Corporation.

No conclusion was reached regard-

ing the name for the $1,000 cash award to a young research worker. It was the belief of the Executive Board that the name should have some significance in research or teaching, and Dr. Work was instructed to discuss this with the ECRC Executive Board and the prospective sponsors.

(b) The plans for the ASEE–NSF Study of Research Needs have been agreed to by both NSF and ECRC. The request for funds has been submitted to NSF, but the grant has not yet been made. The study will be started, under the direction of Dean E. C. Walker, as soon as the funds are received.

(c) The two new ECRC members approved are Worcester Polytechnic Institute and Marquette University.

(d) 817 copies of the Review of Current Research have been sold and about 400 more have been sent to Institutional Members of ASEE. E. C. McClintock is to investigate the requirements for getting a Second Class mailing rate.

3. *Report of ECAC,* W. T. Alexander

(a) The Industrial Fellowship Program is still headed by ECAC Secretary Ralph Morgen. The Executive Board agreed the procedure of having a Council develop an idea until a workable plan and procedure is developed was sound, but that the Society should not have several small offices established to conduct the work for the various Councils; instead, the work of the Society should be concentrated in a single central organization under the direction of the Secretary. The Executive Board VOTED that as of 1 July, 1956, the Industrial Fellowship activity be transferred to the Secretary's office, that this activity then become a Society function, and that a new Society committee be appointed from ECAC and ECRC, the purpose of the committee being to carry out the "random selection" of institutions and to advise the Secretary on other matters pertinent to the fellowship program.

(b) The possibility of having the Society administer the AEC fellowship program was discussed. After much deliberation it was agreed the handling of such a complex program was beyond the scope of activity of the Society. Reasons for the decision centered on the undesirability of having to select recipients and schools, the tremendous variations in capabilities to do atomic research, the problems of administering security provisions, and the requirements for increased staff and space.

(c) The *ad hoc* committee on Accrediting Practices in New York State is working to get the New York authorities for the registration and licensing of engineers to discontinue their own accrediting and accept ECPD accreditation. By law they can accept, at their discretion, accreditation by other organizations.

4. *Report of Vice President in Charge of Sections,* F. C. Lindvall

Details of procedure at the Annual Meeting were discussed. The Secretary noted that Sections needed to understand that members of the General Council continued to serve until ten days after the Annual Meeting, regardless of the time of year when elections had been held.

5. *Report of Vice President in Charge of Divisions,* L. J. Lassalle

Information regarding Divisional publications and methods of financing them has been coming in, and a full

report will be made at the Annual Meeting.

6. *Report of the Treasurer,* G. W. Farnham

(a) The third quarter financial statement was discussed. Receipts and expenditures were in general accord with the budget. The cost of the JOURNAL for the year will be about the same as for last year and within the budget; monthly income for advertising has risen to approximately the level of last year.

(b) The financial status of the eight special projects for which funds have been granted the Society was reviewed. All projects were in satisfactory condition.

(c) As of April 1, 1956 there was a total of $47,679.38 in savings accounts and a balance of $61,831.65, including funds for special projects, in the checking account. It was agreed an additional $10,000 should be placed in a Boston savings bank, W. T. Alexander to provide the Secretary with the necessary information.

7. *Report of the Editor,* E. C. McClintock

(a) The new format, started with the January issue of the JOURNAL, apparently has been well received.

(b) Up to the present time no information has been received which indicates that a saving could be made by printing the Yearbook using an offset process of a quality equivalent to the present letterpress method.

(c) Some secondary school students and advisors have expressed the opinion that the JOURNAL may be good guidance material. This raises the question of whether copies should be placed in libraries of secondary schools.

(d) Cooperation was given John Mattill, Chairman of the Public Relations Committee, in the preparation of the news release for the Humanistic-Social Report.

(e) The Executive Board agreed that the statistics on enrollments and degrees granted should be kept together in one article, the Secretary being instructed to so inform H. H. Armsby.

(f) The suggestion was made that more pictures and biographical sketches were desired, particularly for Society officers, and for chairmen of special projects.

8. *Handling of Funds for Special Studies*

(a) The Secretary reported difficulties arising from some of the present methods of handling funds for special projects. In some cases where funds went directly from grantor to the administering group there has seemed to be a lack of responsibility for "winding up" matters, and the Society seems to have no real responsibility or control. The Executive Board VOTED that in the future when funds are solicited by or in the name of the Society, the money is to remain under the control of the Secretary's office and be disbursed by him as required.

(b) There have been a few cases when travel expenses for committee members from industry were paid by the Society. The Executive Board VOTED not to pay travel expenses for industrial members of committees attending meetings for special studies, and that such a statement be incorporated in agreements with the grantors of funds.

9. *Fund Solicitation*

(a, b.) The financial needs of Sections and Divisions and ways of obtaining the needed funds were

discussed, but no action was taken. F. C. Lindvall submitted information relative to the problems of the Pacific Southwest Section.

(c) The need for increased funds to pay travel expenses for Society representatives on committees of other societies, for General Council members, etc., was discussed. In order to initiate some action, the Executive Board VOTED to recommend to the General Council that dues of Associate Institutional members be increased from $50 to $150 per year and that an *ad hoc* committee of the General Council be appointed to draft an appropriate letter which would notify the Associate Institutional members of the change.

10. *Engineers Joint Council Activities*

(a) The Executive Board VOTED to recommend to the General Council approval of the American Society for Agricultural Engineers as an associate member of EJC.

(b) President Boring reported that EJC's Surveys Committee is functioning under their Employment Conditions Committee. It had been proposed that a joint program could be established for these committees of EJC and our Evaluation Follow-Up Committee. President Boring is to pursue the matter to a satisfactory conclusion.

(c) Dean M. P. O'Brien has been recommended to EJC as the Society's representative on the Joint Committee for the Study of the Engineering Profession.

(d) A memorandum from EJC dated 29 March 1956 stated that the EJC Board of Directors had voted to recommend the deletion of Par. 2, Article VIII of their constitution, which pertains to the use of dues income during the "fiscal year" as the basis for determining "proportionate financial support," and asked for action on the recommendation by the Constituent Societies. The Executive Board agreed that it could see no disadvantages to the deleted plan, and, because this plan enabled an audited figure to be used, instructed the Secretary to write EJC saying the Executive Board recommended that Par. 2 of Article VIII remain unchanged.

11. *Engineers' Council for Professional Development Activities*

(a) At the 1955 Annual Meeting of ECPD it was voted that the Council recommend to each constituent engineering society that they request each new member who joins a particular society to signify his acceptance of the Canons of Ethics, or of the code of ethics of the Society, as a condition of membership. It was unaminously agreed by the Executive Board that ASEE had no need for and would not gain from such a requirement and, consequently, should not require new members to signify acceptance of a code as stated in the ECPD action.

12. *Group Insurance for ASEE Members*

The Executive Board VOTED not to participate in the plan suggested by Smith and Sternau because, if all other engineering societies participate, most ASEE members will already have had an opportunity to participate.

13. *U. S. Mission to Russia*

The Executive Board VOTED that the Society should not ask the State Department for permission to have a five or six man team of engineering educators visit Russia and study the Soviet system of engineering education. It was believed that initiation

of such a project would involve responsibilities the Society should not assume.

14. *Sponsorship of Engineering Society for Junior College Students*

The Executive Board agreed that such inquiries should be referred to the appropriate State Society of Professional Engineers. A study of the records indicates that ASEE had a Junior College Division in 1949; it was unsuccessful because of a lack of interest.

15. *Technical Meetings with High School Teachers*

EJC has requested its constituent societies to consider permitting high school teachers to attend society meetings without having to pay registration fees, or with reduced fees. The Executive Board agreed to refer the matter to the General Council for action, believing it advantageous to do something on the Section level, but doubting that there would be an interest in the Annual Meeting.

16. *Council for Basic Education*

The Society was invited to become an associated organization of the Council, no financial obligation being entailed. As a member of the founding group, President M. M. Boring reported that the Council was financially supported by the William Volker Fund, with the object of getting more as well as better mathematics and science into high schools. The Executive Board agreed to take no action at this time, but President Boring is to keep the Executive Board informed of developments.

17. *Future Meetings*

(a) The Executive Board agreed that the week of June 16 was preferable to the week of June 9 for the Annual Meeting at Berkeley in 1958.

(b) The Secretary called attention to the fact that if the geographical rotational scheme for holding meetings was adhered to, the 1960 meeting should be held in the South or Southeast.

(c) The Fall meeting of the Executive Board follows the ECPD meeting, as previously agreed, and is to be on Friday, October 26, 1956. A 6:00 P.M. dinner meeting will be held at the Engineering Society of Detroit, Detroit, Michigan.

(d) The Fall meeting of the General Council also follows the ECPD meeting, as previously agreed, and is to be on Saturday, October 27, 1956, at 7:30 A.M. The breakfast meeting is scheduled for the Ivy Room at the Statler Hotel, Detroit, Michigan.

(e) The Secretary reported that, regrettably, the American Society of Physics Teachers will not meet jointly with ASEE at Cornell in 1957.

18. *Deans' Conference On Atomic Energy*

The letter ballot of the General Council overwhelmingly approved the program. ASEE, the Atomic Energy Commission, the National Science Foundation, and the Oak Ridge Institute for Nuclear Studies are joint sponsors. NSF is providing the funds for travel and *per diem* expenses. The dates are September 5–8 at Gatlinburg, Tennessee. All deans of engineering of ECPD approved schools, the presidents of those institutions, the members of our Atomic Energy Education Committee, and the President and Secretary of ASEE are to be invited. Plans are being developed by our Atomic Energy Education Committee.

(For items 19 and 20, please see page 803.)

ECPD Additional Criteria for Accreditation

INTRODUCTION AND BACKGROUND

HAROLD L. HAZEN

Chairman, Education and Accreditation Committee, ECPD
Dean of the Graduate School, Massachusetts Institute of Technology
Cambridge, Massachusetts

Since the Engineers' Council for Professional Development (ECPD) began accreditation of undergraduate engineering curricula in the early 1930's, there has been continuing discussion of the question "What is an engineering curriculum?" The long-established and recognized fields, beginning with Civil Engineering, are clearly engineering, but how about Geological Engineering or Engineering Physics? Are curricula in these fields appropriately regarded as engineering curricula or not? Such curricula were often informally called "fringe" curricula in ECPD, a designation that did not question the quality but only the field of the curriculum for purposes of accreditation.

In an attempt to answer this question after discussions extending over a period of years, Council of ECPD, on recommendation of the Education Committee, approved as a principle of operation a statement concerning so-called "fringe" curricula which appeared in the twenty-second *Annual Report* (September 30, 1954) of ECPD and was published in the January, 1955, issue of the JOURNAL of ENGINEERING EDUCATION. In this statement there were recognized two categories of engineering curricula, viz., *major* engineering curricula and *cognate* engineering curricula. A set of semi-quantitative criteria was given by which either a major or cognate curriculum could be tested. If a curriculum satisfied these tests or criteria, it was considered by ECPD to qualify as an engineering curriculum. This was a step in the direction of placing relatively more emphasis on the nature and content of the curriculum than on its name in determining whether or not it qualified as an engineering curriculum for purposes of accreditation.

Although little discussion occurred concerning the criteria, much and indeed rather violent opposition developed among some whose curricula had been designated as "cognate." These maintained that any curriculum that was not major was obviously minor, and therefore inferior in status. "Cognate" status was unacceptable, however respectable Mr. Webster might consider it.

But discussion over the so-called "cognate curriculum" statement paved the way for the next step, which was to disregard the name and look entirely at the nature and content of the program

to determine whether or not it would qualify as an engineering curriculum. Working in this direction, the Education Committee of ECPD prepared a statement of "Additional Criteria for Accreditation of Engineering Curricula" to supersede the unacceptable "cognate" statement. In principle this "additional criteria" statement says that the name of an engineering curriculum is of minor concern to ECPD and is primarily the business of the institution offering the curriculum. What ECPD *is* concerned with is the character and content of this curriculum. This "statement of additional criteria" was accepted as a working principle by the Council of ECPD in Toronto on October 16, 1955, and appears as a part of the report of the Committee on Education and Accreditation in the twenty-third *Annual Report* of ECPD, dated September 30, 1955.

It should be emphasized here, as it is in an indication itself, given below, that the additional criteria are not a set of rigid, inflexible rules, but rather an indication of what are regarded as sound principles which will serve as a guide in ECPD appraisals for a least a year or two. In regarding this statement as a guide rather than a set of rigid rules, it is meant, for example, that a curriculum might technically satisfy all of the additional criteria and yet be taught under such circumstances that ECPD could not approve it for accreditation. On the other hand, a curriculum might fall somewhat short of meeting these criteria in certain respects and yet be taught by such a faculty and under such circumstances that it was clearly a strong engineering curriculum and therefore acceptable for ECPD accreditation. Therefore these additional criteria are merely a part, albeit an important part, of the criteria used by ECPD in its evaluation.

In the "additional criteria" statement and in exercising broad judgment regarding minimum acceptable standards, ECPD is taking fully into consideration the report of the ASEE Committee on Evaluation of Engineering Education. Eleven members served on both the Education Committee of ECPD and the Evaluation Committee of ASEE, so the cooperation has been close. It should be emphasized, however, that the objectives of the reports presented by the Evaluation Committee and by ECPD's Education Committee differ in one important respect. The Evaluation Committee's function was to formulate a pattern and ideals for the improvement of engineering education applicable to strong as well as to less strong schools. The ECPD function, on the other hand, is basically to set and to act in accordance with *minimum* standards for accreditability. Thus, while there is a close relation between the two activities, the ends or objectives are different; consequently the *ideals* of the Evaluation Committee should differ from a statement of *minimum standards* for ECPD accreditation.

ADDITIONAL CRITERIA FOR ACCREDITATION OF ENGINEERING CURRICULA

As approved in principle by the Engineers' Council for Professional Development at its Twenty-Third Annual Meeting, Toronto, Canada, October 13–14, 1955.

1. In order to assist identification and recognition by ECPD accreditation of those curricula that constitute adequate undergraduate educational preparation for engineering, the following criteria supplemental to those regularly published in the Annual Report of Engineers' Council for Professional Development under "Objectives and Procedures" for Accrediting Engineering Curricula will serve as a guide in ECPD accrediting activity. These criteria have as their object the assurance of an adequate foundation in science, humanities, engineering science, and introduction to engineering method, while providing sufficient flexibility in science requirements to accommodate curricula requiring special backgrounds, such as life science or earth science. They also provide substantial flexibility for expression of the institution's own individuality and ideals. Finally, they are regarded as a statement of principles to be applied with judgment in each case rather than with arbitrary rigidity.

2. The supplemental criteria are:

a. All curricula shall contain at least the equivalent of one academic year of mathematics and basic science about equally divided.

b. All curricula shall contain at least the equivalent of approximately one year, except as provided in 2-c, of engineering sciences, including most and preferably all of the following:

1. Mechanics of solids (statics, dynamics, strength of materials)
2. Fluid mechanics
3. Thermodynamics
4. Transfer and rate mechanisms (heat, mass, momentum)
5. Electrical theory (fields, circuits, electronics)
6. Nature and properties of materials (relating particle and aggregate structure to properties)

Only after careful consideration and determination that the fundamental concepts are substantially covered in other studies at an equivalent mathematical level, should one of these engineering sciences be omitted from a curriculum.

c. Because some engineering curricula are built in part on sciences not included in the preceding paragraphs, such curricula may contain for additional flexibility other basic or engineering sciences appropriate to their fields, to an extent equivalent to one-third of an academic year, in lieu of an equal portion of time otherwise devoted to the engineering sciences listed in 2-b.

d. Approximately the equivalent of one-half of an academic year shall be devoted to engineering analysis, design, and engineering systems.

e. The curriculum shall be designed as an integrated sequential study in the scientific and engineering area.

The mathematics and the basic science are to be used proficiently in the work in engineering analysis, in the study of engineering systems, and in the preparation for creative design.

f. The equivalent of one-half year to one full year of the curriculum shall represent the minimum content in the area of humanistic and social studies. Of this content, at least one-half year should be selected from the fields of history, economics, government, literature, sociology, philosophy, psychology, or fine arts, and should not include such courses as accounting, industrial management, finance, personnel administration, or ROTC.

g. The two pressures on four-year engineering curricula for inclusion of more newly developing engineering science and for an increase in the social-humanistic content make it necessary that neither the technical-scientific nor the social-humanistic content of such curricula be reduced below the minimum requirements of paragraph 2 above to make room for advanced ROTC programs. This procedure views realistically the fact that the engineering student taking advanced military science is in effect pursuing two curricula simultaneously with separate and different requirements and objectives.

3. In any case in which the Education and Accreditation Committee is persuaded that well-considered experimentation in engineering curricula is under way, it shall give sympathetic consideration to departures from the criteria of Sec. 2 and shall make appropriate recommendations to ECPD.

4. The committee recognizes that these recommendations constitute a departure from past practice in that an approach is made to quantitative criteria for curriculum content and distribution of time.

5. The committee continues to favor broad basic undergraduate programs in engineering which will prepare a student to take advantage of as many different opportunities as possible, and prefers to minimize the number of specially designated curricula to be considered for accreditation. The committee is prepared to examine for approval any curriculum that appears likely to satisfy its criteria for an undergraduate engineering curriculum.

Curricula of a vocational or technical institute pattern cannot qualify, nor can curricula of so specialized a pattern as to provide an inadequate base for engineering of professional level.

MEET YOU AT AMES

Report of the Prototype

CHICAGO INDUSTRY–EDUCATION CONFERENCE

on the ASEE Evaluation Report

The following condensation represents the major thinking at an exploratory conference held March 6, 1956, in the Western Society of Engineers Headquarters, 84 East Randolph Street, Chicago. The purpose of the meeting was to invite an expression of industrial views about the pattern of engineering education set forth in the ASEE *Evaluation Report*. Executives from industry in and around Chicago, members from the Committee on Evaluation of Engineering Education, and administrative and faculty representatives of the midwestern Engineering colleges attended the conference.

Two discussion sessions and a luncheon made up the meeting. Both sessions were based on the text of the *Evaluation Report*, which had been distributed previously. Written expressions of opinion were also invited and then incorporated, with numerous suggestions received. Significant excerpts are presented below, both for their intrinsic interest and as a possible aid in arranging similar discussions throughout the country. (Outlines of procedures have also been prepared, and are available from the Follow-Up Committee.)

The prototype group assembled on joint invitation by Mr. H. P. Sedwick, President of the Public Service Company, Chicago, who served as principal discussion leader, and Dean W. L. Everitt, College of Engineering, University of Illinois, chairman of the ASEE Follow-Up Committee on the Evaluation Report. Attendance, especially from industry, exceeded expectations, and discussion interest was high.

The principal views expressed emphasized that the *Report* recommendations definitely looked in the right direction, toward a well-rounded engineering graduate with sound, basic learning readily transferable to any field of professional activity. Though there is always need and possibility of improvement in engineering education, the key problem facing technical colleges today is that of obtaining and holding adequate numbers of superior faculty members. Better utilization of faculty talents without loss of teachers can be achieved through part-time efforts both in research and in stimulation of industrial thought. These gains can be achieved with the wise assistance of industry.

The Graduate

Some of the major needs of engineering graduates appear to be for improved skill in communication and logical thinking, the development of creative imagination in design and problem-solving, administrative capacity and ability to deal effectively with other people, plus high ethical and professional standards and sense of responsibility. It was agreed that these should continue to be developed,

under industry tutelage, for many years after graduation.

Colleges are primarily responsible for instruction in basic science, effective communication, and a well-rounded background in humanistic studies. In contrast, engineering arts and "know-how" required for industrial purposes can best be taught by the companies themselves, whether large or small. The professional engineering societies can be a great help to students entering engineering, especially in obtaining proper high-school preparation. There is a need for improved communication between industry and educational institutions, and this is essential for mutual understanding and aid. With a wide circulation of the Evaluation Report and subsequent meetings of similar industry-education groups, possibly with secondary school officials in attendance, it is believed that by joint action many problems can be solved.

Program in Detail

The session was opened with a brief explanation of the *Evaluation Report* objectives, emphasizing (a) the high qualifications needed in engineering teachers, (b) the need for a liberal point of view in all courses, (c) mutual strengthening of relations between teaching and research, and (d) the distinction between *science or analysis* (seeking answers to questions of what happens under given circumstances) and *engineering or synthesis* (the use of materials and natural laws or forces to obtain desired results). The need for re-orientation of engineering curricula toward both basic and engineering sciences, including humanities, was also developed.

The critical problem for colleges and universities is that of obtaining expanded high-quality faculties and facilities for instruction. A youthful point of view and adaptability to new conditions is considered essential for teaching success, after subject-matter competence.

Industry can help most in supplementing salaries and opportunities of engineering faculties by encouraging teachers to act as consultants, as research investigators within their own college, and as idea-sources, but not by recruiting them as full-time industrial employees. Thus staff members can continue their teaching while they contribute to scientific knowledge and industrial success. Industry thereby can stimulate effectively the production of engineering graduates in greater numbers for the future.

Summer employment programs, if realistically priced at something like 50% of winter-session salaries, can also be of significant assistance to engineering faculties. Industry can gain the advantage of both university and industrial facilities by employing teachers' productive-thought time at home, in their own colleges. It was also suggested that engineering deans recommend younger men, as well as more mature staff members, for consultant assignments to gain industrial training and practice. Such experience will reflect beneficially on teaching and will encourage top-quality performance.

The industrial representatives emphasized that engineering faculties are now doing a good job and that industry suggestions are aimed only at the improvement which is always possible, even under the best of circumstances.

A Chicago industry representative felt the *Report* was particularly strong in urging study of the basic sciences

first, followed by the engineering sciences. The practical side of engineering, he felt, can best be obtained in business after graduation; colleges should establish a sound basis for this later development. Special educational topics are less important than the personal guidance and stimulus of brilliant instructors.

Cooperation and Thought

Another industry representative from the Chicago area pointed out that students need to realize the difference between cooperative or conference work in contrast to the dreariness of single labor and the loneliness of individual thought. However, an engineer needs patience and an objective view of others, as well as of himself, for successful teamwork.

An employment director noted that while top engineers might logically be expected to evolve into managers or executives, he had encountered a surprisingly negative student reaction to the importance of English, a basic management tool. Most students, he felt, were likewise either completely inadequate or seriously deficient in *science* preparation (75% for entering students, according to a survey by an Eastern university).

An executive of a heavy equipment firm expressed the belief that there is an important difference between English, and humanities or other non-professional courses. Practice in effective expression, he felt, is an essential part of professional training. He was inclined to resist weakening the curriculum with too much humanities, but felt that English should be included as a major aspect of professional studies in engineering.

At Chairman Sedwick's invitation to comments on curricular revision or improvement of teaching, an educational administrator stated that, in line with the recommendations of the *Report,* his institution had disposed of its electrical machinery laboratory and equipment. In removing limitations on imaginative thinking, he considered this to be at least experimentation, if not revolution.

An executive of a leading electrical manufacturing company reported that the constantly increasing size and complexity of industry calls for much more *general* education and capabilities than in the past. The engineering graduate today needs to be well-rounded, with diverse competencies, not narrow and highly specialized. Also, he felt that an undergraduate curriculum in any branch of engineering, plus graduate study in business administration (with a considerable segment of humanities courses in each), would be of great assistance.

The executive of the heavy equipment firm mentioned above suggested a research study of non-engineering skills among engineering employees in industry. Topics to be considered could include the background of these skills, when and where they were acquired, and the means or methods most successful in the development of knowledge, sympathy, and insight.

As the meeting progressed, the spirit seemed increasingly concerned with how to help engineering education, especially engineering faculties, rather than with possible defects of the *Report.* A strong inclination was expressed to accept the *Report,* to conclude that its recommendations were valid, and to insist that the major problem was implementing them and pushing them further. This should be done, it was thought, through providing funds both to engineering and

liberal arts institutions in the hope that they would be able to carry out their functions even more effectively than now. The consensus was one of industrial encouragement to engineering education in carrying out its present work.

Discussion developed next on the dangers of using industrial funds for scholarships only. It was suggested that specific contributions be made to faculty salaries and to the improvement of teaching facilities rather than for general building and grounds purposes. Industry can help faculty members, for example, with grants toward attending summer schools. The dean of a midwestern technological college pointed out that faculties are anxious to study and improve themselves, given the requisite funds and opportunities.

A member of the Evaluation Committee from a Southern university made an extended point that the problems of engineering education were accentuated by the threats of Russian efforts and progress, both in quantity of engineering students (two to one against the United States) and in quality as well. To illustrate, he cited the 1939 situation in electronics, which now has a parallel in the fields of physics and nuclear chemistry. He expressed the belief that dynamic and bold improvements in engineering education are required if we are to be successful in competing with the highly organized Russian system.

He also emphasized that *creative* attitudes are needed in both faculties and engineering graduates, and that impetus must be given to the continued *general education* of the individual. Fixed curricula can serve to "deep-freeze" new ideas; curricular *revision* can stimulate them. Today we need emphasis on the *basic ideas.*

Broad training is important also because graduates so often *change fields* completely in practice. Subjects such as accounting, management, and ROTC are neither science or humanities, and should be considered separately, outside the curriculum, in terms of the quality of their contribution.

In reply to questions, the industrial representatives felt that a streamlining of courses in traditional drawing, in shops and laboratories, and in design would not weaken engineering education. Industry seemed to have faith in the educators' ability to deal with problems of curricular balance as an educational responsibility primarily. There were no indications that industry would be dissatisfied with engineering graduates who possessed broader and more scientific backgrounds.

A practicing civil engineer considered the *Report* a good piece of self-criticism for engineering education and a fine "handbook of desirable practice," with a useful balance of science, engineering science, and humanities. More emphasis and importance, he believed, should be placed on the responsibility of graduates to the *engineering profession*, as members of engineering societies and organizations. He felt that four years were enough for undergraduate training, but that more on-the-job-training and practice would be helpful. Industry often fails to utilize engineers properly and to continue professional education at higher levels. A coworker added that their feelings as civil engineers were not disturbed by the implications of the *Report* for civil engineering.

A Committee representative from Purdue University offered the suggestion that if the important function of teachers in colleges was that of stimulating students, instructors should also be important to industry for their creative ability.

Another civil engineer from the steel industry spoke of the graduates he encountered who lacked a practical command of English. He agreed on the desirability of extended basic training, and illustrated with the experience of a leading electrical instrument manufacturing company, which found *physics* graduates to be more useful than electrical engineers.

A consulting civil engineer contrasted the basic European approach to engineering education in his native Norway with the relatively "handbook" methods prevalent in the United States. He preferred more emphasis on "thinking out" problems rather than on finding formulas into which data could be fitted. (Throughout the conference, the recurrent theme was the need of engineering graduates for skill in logical and imaginative thought processes.) This engineer expressed appreciation of his three years experience as a teacher, and recommended a tour of teaching duty for all superior engineering graduates.

An industrial administrator noted a new attitude of industry toward the development of executive talent. The training of executives is now industry's responsibility. A graduate of three years experience is no longer expected to be capable of vice-presidential responsibilities. Employing companies can and should enhance administrative skills if education will lay a sound and broad foundation for either technical or administrative advancement. Industry, whether small or large, can well bear the burden of practical training in engineering arts —even by organizing summer programs with university staff members as instructors.

Conclusions

It was agreed that

(1) The aim of the *Report* was to plot goals and directions for engineering education over the next 25 or 30 years; this had been done effectively.

(2) The *Report* should be more widely distributed and read, with the aim of obtaining all possible application for its existing recommendations, and of adding comments or suggestions from both industry and education sources.

(3) Improved communciation between industry and education is most important for the further development of engineering education. It was suggested that additional regional meetings of this type, combining representation from the Committee, from industry, and from engineering education, be held to develop better understanding and mutual assistance. The industry members felt particularly that they had gained from the conference a much more vivid sense of educational problems, and now saw much more clearly than before the many opportunities to employ engineering faculty members part-time, and how to utilize the skills and resources of engineering colleges.

(4) Finally, it was believed that joint action by industry, professional engineering societies, and engineering educators should go a long way to solve the problems of engineering education and to advance the interests of the profession and the nation.

SECTION MEETINGS

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pennsylvania State University	April 27–28, 1957	B. A. Whisler, Pennsylvania State University
Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Wichita	Oct. 26–27, 1956	J. K. Ludwickson, University of Nebraska
Michigan	Wayne University	May 5, 1956	G. H. Howell, Wayne University
Middle Atlantic	Bell Telephone Laboratories, Murray Hill, N. J.	May 12, 1956	G. B. Thom, Newark College of Engineering
Missouri-Arkansas	University of Arkansas	April 6, 1957	L. R. Heiple, University of Arkansas
National Capital Area	Capital Radio Engineering Institute, Wash., D. C.	Oct. 11, 1955	W. J. Huff, University of Maryland
New England	Tufts University	Oct. 19–20, 1956	W. S. Evans, University of Maine
North Midwest	South Dakota State College	Oct., 1956	J. W. Howe, State University of Iowa
Ohio	University of Toledo	April 26–27, 1957	E. D. Harrison, University of Toledo
Pacific Northwest	University of Washington	May 10, 11, 12, 1956	M. C. Jenson, Washington State College
Pacific Southwest	University of Arizona	Dec. 28–29, 1956	D. Whelan, Loyola University of Los Angeles
Rocky Mountain	Denver University	April 28, 1956	W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7, 1956	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas A. & M. College	April 18–19, 1957	E. M. Thomas, Texas Western College
Upper New York-Ontario	Schenectady	Oct. 12–13, 1956	W. H. Branch, General Electric Company

Members of the Society are welcome at all Section Meetings

Members have requested that the application blank be reproduced more often, so that it could be available for potential new members. Accordingly, it is printed below.

APPLICATION FOR MEMBERSHIP

Date .....

I desire to become a member of the American Society for Engineering Education and hereby agree to conform to the requirements of membership, if elected, and submit the following statement of qualifications:

Name .....
Print last name First Middle

Mailing address .....

City and State .....

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professional position .....
Title Department

Institution ..... Date of Birth .....

Degrees and names of institutions granting .....

Sponsors .....

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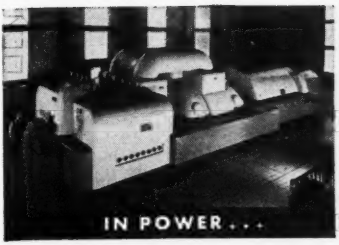
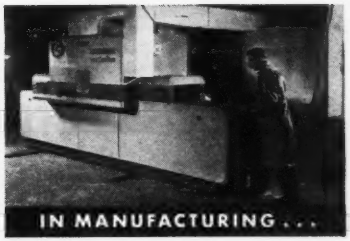
Desired Division Affiliation .....

To be signed by two sponsors, members of ASEE, and returned to
W. L. Collins, Secretary, ASEE, University of Illinois,
Urbana, Ill.





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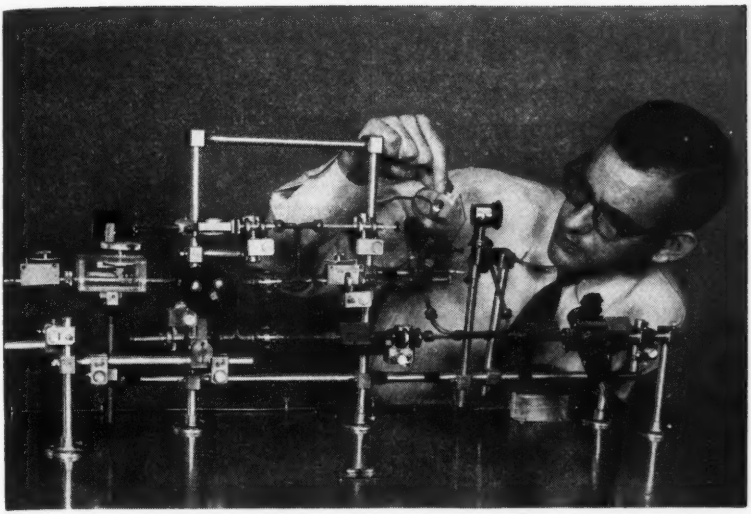

Physicist G. K. Farney checks the frequency of Bell's new klystron, which is located at far right. Tube's output is about 20 milliwatts.

Sixty billion vibrations per second

A great new giant of communications—a waveguide system for carrying hundreds of thousands of voices at once, as well as television programs—is being investigated at Bell Laboratories.

Such a revolutionary system calls for frequencies much higher than any now used in communications. These are provided by a new reflex klystron tube that oscillates at 60,000 megacycles, and produces waves only 5 mm. long.

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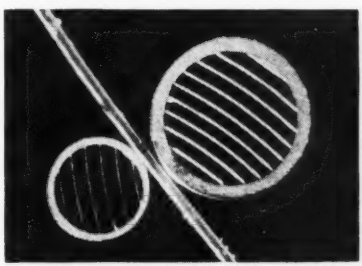

Grids in new tube, enlarged 30 times, with human hair for comparison. Electronic beam passes through smaller, then larger, grid.

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